A

PRACTICAL TREATISE

ON THE

RAW MATERIALS AND FABRICATION OF GLUE,

GELATINE, GELATINE VENEERS AND FOILS, ISINGLASS, CEMENTS, PASTES, MUCILAGES, ETC.,

BASED UPON ACTUAL EXPERIENCE.

BY

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TRANSLATED FROM THE GERMAN, WITH EXTENSIVE ADDITIONS, INCLUDING A DESCRIPTION OF THE MOST RECENT AMERICAN PROCESSES,

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PREFACE.

THE importance of glue and gelatine, by reason of their constantly-increasing consumption in the arts and for culinary and medicinal purposes, has rendered necessary some instruction relative to their manufacture. In the multitude of books, treating of every conceivable subject and matter, which have issued from the prolific press of the United States during the last ten years, there is none which treats of this important branch of industry. The only information in regard to it is scattered through encyclopædias, chemical books, etc., difficult to find and troublesome to study.

The object of this work is to present to the reader, in a handy and comprehensive form, complete information regarding the subject. The work upon which the book is mainly based is an excellent one, and has met with great success in Germany, it being thoroughly practical and easily comprehended by the ordinary workman.

Like nearly every other branch of industry, the manufacture of glue and gelatine has lately made great progress towards perfection. Ingenious and practical men have devoted their energies to actual

experiments, and the aid of chemistry has been invoked until the manufacture has been lifted from the slough of stagnation, into which it was sunk for so many years, to the position of a great industry, carried on in immense establishments, and giving employment to a large number of workmen. In the following pages will be found the principal improvements in machinery and manufacture up to the present date, due regard having been given to the present advanced American practice, as well as a description of the various and numerous uses of the manufactured product, and full instructions for preparing the compounds of which it forms a constituent.

To make the book still more acceptable to the manufacturer, mechanic, artisan, and artist, for whom it is especially intended, a treatise on the manufacture of cements and pastes has been added.

Great care has been used in selecting the receipts, and only such have been given as have stood a practical test and can be recommended. Many of the receipts are entirely new. The entire work has been compiled with a view to practical utility, so that whether the article to be mended is a fine China vase or a defective iron casting, a suitable cement will, by referring to the following pages, be readily found.

W. T. B.

PHILADELPHIA, April 21, 1884.

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PRACTICAL TREATISE

ON THE

MANUFACTURE OF GLUE.

I.

WHAT IS GLUE?

1.—Sources of Glue.

When certain substances contained in the animal organism are boiled for some time with water, the solution so obtained sets to a jelly on cooling. The result of drying the jelly will be a solid, brittle, glassy product, of a light-yellow to black-brown color, which is known as glue.

The following materials, being richest in glue-yielding substance, are of the most importance to the glue boiler: Scraps of ox and other thick hides, the tendons and intestines of many animals; tissues of bones, cartilages, lymphatic vessels, buckshorn, the swimming bladder of many fishes, fish scales, etc. Rabbit skins, deprived of their fur, scraps of parchment, old gloves, and many other apparently worse than useless matters, all contribute their quota in the manufacture of glue.

Glue does not pre-exist in the animal organism, except under abnormal conditions, as a phenomenon of disease, but is the product of several transformations. The first of these takes place in drying the hide, as the result of boiling green hide prepared in the usual manner, by liming, etc., but not dried, will be an entirely different product of less consistency than that obtained by drying the hide after liming and then boiling. A second transformation seems to take place in boiling the material, and a third in drying the obtained jelly, which may explain the fact that the latter, which is not yet converted into actual glue, differs in its behavior from glue solution. The series of transformations does not end even with the actual glue, for it is a well-known fact, that glue dissolved in water, and boiled for some time, does not gelatinize on cooling, but remains liquid. We have here to deal with an organic combination, differing from the more solid inorganic ones, by passing more quickly into decomposition, and more readily from one combination into another.

2.—Distinction of the Various Transition Stages of Glue.

We distinguish therefore :—

a. Glue-yielding substance.
b. Crude Glue.
c. Jelly.
d. Glue.

a. Glue-yielding substance is produced by the animal economy from proteine bodies, albumen, fibrine and caseïne in a manner similar to that in which new substances are formed in the ripening fruit by the transformation and separation into constituent parts of others previously present.

b. By *crude glue* we understand glue-yielding substance freed from all foreign matter, and physically prepared by drying. It forms an intermediate link between glue-yielding substance and jelly.

We believe that, by reason of our experience, we are justified in making this distinction between glue-yielding substance and crude glue. Lime carefully, for instance, fresh calves' heads, such as the tanner cuts off after raising the skin, and then boil them without previous drying, the result will be a turbid soup, containing, though everything be dissolved, no jelly whatever, or, at least, very little.

c. Jelly is obtained by boiling the crude glue. Its adhesive power is far less than that of solution of finished glue, and it will become more quickly putrid than the latter.

d. The finished product *glue* is, in most cases, not a definite chemical combination, but a mixture of substances, with two of which scientific research has made us thoroughly acquainted.

3.—Characteristics of Glue.

Independent of impurities and accidental constituents, glue consists of two distinctly distinguishable

combinations, *a*, *glutin*, and *b*, *chondrin*, the former being formed from the hide and osseous parts, and the latter from the young bones, whilst yet in a soft state, and the cartilage of the ribs and joints.

The manufacturer has it, of course, in his power to allow either of these substances to predominate in his product, but since experiments have shown glutin to possess much greater adhesive power than chondrin, it is advisable to separate as much as possible the cartilaginous matter from other glue-yielding material.

It is possible that a more careful study of chondrin may prove it to be possessed of qualities which would make the manufacture of it by itself desirable.*

As an accurate knowledge of these constituents of glue is of the greatest importance to the manufacturer, we will here briefly state what scientific research has made known to us in regard to them.

Pure glutin is obtained by submitting buckshorn, etc., to the action of water mixed with hydrochloric acid, until the calcium phosphate serving, so to say, as a frame for the glue-yielding substance, is dissolved and only the glue cartilage remains behind. After freeing the latter from fat by steeping it in milk of lime and careful washing, it is boiled, and the resulting jelly, when cold, mechanically distributed in cold water, in which it softens, but does not dissolve. By thoroughly stirring the mass the glutin yields its

* It is now largely manufactured and used as a size.—*Translator.*

coloring matter to the water, which must be replaced by fresh water until all coloring matter is extracted. Then pour off the water, and after dissolving the jelly in hot water, filter the solution through a cloth. By mixing the filtered solution with an equal volume of alcohol, a precipitate of pure glutin is obtained. When dry, pure glutin is almost colorless, transparent, hard, and endowed with great, but variable coherence according to the kind of material from which it is obtained. It is inodorous and insipid. Its specific gravity is greater than that of water. It exerts no influence whatever upon vegetable colors, and has a neutral reaction. It is insoluble in spirit of wine, ether, fat, and volatile oils. In cold water it softens, absorbing as much as 40 per cent., intumesces, becomes opaque, but does not dissolve. A liquid which contains one-hundredth part of its weight of glutin becomes viscous on cooling, but when it has only the one-hundred-and-fiftieth the menstruum remains fluid.

An aqueous solution of glutin is precipitated by chlorine, platinum bichloride, tannin, and alcohol, but not by hydrochloric acid, acetic acid, sugar of lead, alum, and ferric sulphate. By dry distillation glutin gives ammonium carbonate, ammonium sulphide, ammonium cyanide, amines, pyridine bases, pyrol, and other compounds, and by boiling with dilute sulphuric acid, glycocoll and leucine, and other products.

When heated, glutin diffuses a peculiar odor, enters into a state of semi-fusion, bends, tumefies, and then exhales the odor of burnt horn. In the air it takes

fire with difficulty, smokes, flames only for a few minutes, and leaves a bulky charcoal difficult to incinerate, the ashes of which consist principally of calcium phosphate.

Glutin, when in the jellied state, and treated with alcohol, undergoes a dehydration, under the influence of which it contracts greatly. It was by this means that *Gonnor* succeeded in reducing in a remarkable degree the size of a print obtained in a very hydrated film of glutin, and transferring it, so reduced, to stone, from which he obtained a new impression, quite similar to the first, but more or less diminished.

By taking these prints, on the contrary, with glutin very little hydrated, and afterwards steeping them in water, a dilatation of the plate is obtained, which enlarges the figures with the same regularity.

Pure *chondrin* is prepared by boiling for from 24 to 48 hours the cartilages of the ribs, of the larynx with the exception of those of the epiglot, or of the windpipe and the bronchi.

Chondrin is precipitated from its solution by spirit of wine. The precipitate is redissolved in warm water, evaporated, and dried. It forms a semi-translucent mass of a slightly yellow color and resembles glutin as regards fracture and all external properties, but differs from it in being precipitated from it aqueous solution by mineral acids, sugar of lead, alum and ferric sulphate, and also by organic acids such as vinegar, citric and oxalic acids, none of which precipitate glutin.

Chondrin, as regards its chemical composition, is poorer in nitrogen than glutin, and contains more sulphur. Its formula approaches more closely that of albumen, which corresponds also with the origin of chondrin, for the cartilages may be considered as transition-links between the proteine and glue-yielding substances.

By treating chondrin with sulphuric acid, it gives only leucine. By caustic potash it is transformed into glutin and yields then, like the latter, leucine and glycocoll. By boiling with concentrated hydrochloric acid, it yields a fermentable sugar to which the term chondroglucose has been applied.

4.—Properties of Glue, and its Behavior towards other Substances.

Glue, as found in commerce, is always a mixture of glutin, chondrin, and other substances not yet accurately determined. Its quality depends on the crude glue and glue-yielding material used for the production of the jelly.

We would here remark that even if the quantity of glutin contained in the various combinations could not be determined by scientific means, the product obtained from the different glue-yielding materials can be readily distinguished by external characteristics. Every manufacturer knows that glue from hides differs from bone-glue in adhesive power, elasticity, and fracture, and that a larger yield of glue and of greater coherence

is obtained from the glue-yielding tissues of old animals than from those of young and weak ones. Glue from fish-bladders and scales, though consisting mainly of glutin, differs materially in its behavior from hide or bone glue.

Generally speaking, the jelly, no matter whether consisting of glutin or chondrin, possesses, before drying to glue, different properties from glue solution. It has less power of adhesion and spoils more quickly. At a temperature of 16° to 18° R. (20° to 22.5° C., 68° to 72.5° F.) jelly putrefies inside of 24 hours, smells of ammonia and decomposes, while glue solution can be kept much longer without suffering deterioration.

The jelly absorbs ozone with avidity and is decomposed by it, this being the reason why an approaching thunderstorm may cause great damage by destroying the coagulating power of the glue soups, or causing the glue to turn on the nets, *i. e.*, to lose its consistency and become liquid and foul.

The behavior of glue solution towards different salts also deserves attention.

By adding potassium or sodium carbonate, neutral potassium tartrate, Rochelle or Epsom salts to a lukewarm fluid containing 15 to 20 per cent. of glue, the latter coagulates by the salt withdrawing the water from it. A lukewarm solution saturated with common salt, sal ammoniac, saltpetre, or barium chloride does not gelatinize.

By adding to glue solution a large quantity of alum, the glue is precipitated as a transparent mass.

Glue compounded with dilute hydrochloric acid does not gelatinize by itself, but will do so on adding common salt.

Boiling with slacked lime deprives glue solution of its power of gelatinizing, and changes it, on evaporation, into a gum-like colorless mass soluble in cold water and in saturated solution of common salt.

By repeated boiling and cooling (for about six days), glue solution loses its property of gelatinizing.

Tannic acid is a valuable and delicate test of the presence of glue. When added to a solution containing only one-five-thousandth part of glue, nebulosity is immediately apparent. When more concentrated gelatinous fluids are treated with tincture or infusion of galls, a dense, white, caseous subsidence occurs, which, on desiccation, becomes brownish-yellow, agglutinates, and forms a hard brittle mass, easily reduced to powder, soluble in potash lye, but insoluble in water, ether, and spirit of wine. This precipitate is closely allied to the combination of tannin with skin which we call leather.

Glue exposed to a dry heat melts, diffuses a disagreeable strong odor of burned horn, and leaves a charcoal having a powerful discoloring effect like animal charcoal. By dry distillation it gives an aqueous solution of ammonium carbonate and a thick brown oil consisting of a mixture of ammonium carbonate, sulphur, ammonium cyanide, etc.

Chemically glue is composed of:—

	Per cent.
Carbon	49.1
Hydrogen	6.5
Nitrogen	18.3
Oxygen and Sulphur . . .	26.1

which may be represented by the formula: $C_{12}H_{10}N_2O_4$.

The composition of glue differs but little from that of the glue-yielding substance. Isinglass is composed of:—

	Per cent.
Carbon	49.5
Hydrogen	6 9
Nitrogen	18.8
Oxygen	24.8

This justifies the assumption that glue in its various transition stages does not represent different chemical combinations, but only modifications of one and the same combination distinguishable from each other by physical characteristics, as is the case with starch, which, without suffering an alteration in its composition, appears as dextrine and grape-sugar, or as with cellulose, which, without altering its composition, can be transformed into amyloid and grape-sugar.

5.—Tests for Glue.

It is important that the manufacturer and dealer should know how to test the quality of glue. This can be accomplished either by ascertaining the percentage of glutin by chemical means, or the adhesive power in a mechanical way.

The percentage of glutin in a glue solution is estimated by precipitating it with tannin, filtering, drying, and weighing the precipitate, and by calculating from the amount of tannate of glue obtained (the composition being taken in 100 parts at 42.74 parts of glutin and 57.26 of tannin) the quantity of pure glutin in the glue. *Bisler-Beumat*, while employing the same principle, prepares two normal fluids, one of which contains 10 grammes (0.35 oz.) of pure tannic acid to the litre (2.11 pints), while the other contains in 1 litre (2.11 pints) 10 grammes (0.35 oz.) of pure isinglass and 20 grammes (0.7 oz.) of alum. As equal bulks of these fluids do not saturate each other, the author determines by titration the relation between them, and dilutes the tannic acid solution with the requisite quantity of water. In order to test a glue, he dissolves 10 grammes (0.35 oz.) of the sample to be tested with 20 grammes (0.7 oz.) of alum in a litre (2.11 pints) of water, heat being applied if necessary. Next 10 cubic centimetres (2.74 fluidrachms) of the tannic acid solution are taken to which an equal bulk of the glue solution is at once added, because one may be sure that this is not too much, as no sample of glue

met with in commerce is as pure as isinglass. The vessels containing the mixed liquid being well shaken and the precipitate having settled, another cubic centimetre (0.27 fluidrachm) of glue solution is added to the tannin solution, which is next filtered through a moistened cotton filter. If *one* drop of the glue solution still produces a precipitate in the clear filtrate, another cubic centimeter is added to the tannin solution, and then again filtered, these operations being repeated until the filtrate is no longer rendered turbid by the glue solution.

According to numerous examinations made by skilled technologists, the quantity of glutin contained in different kinds of glue varies between 68 and 81 per cent.

The chemical modes of testing glue give only the quantity of glutin contained in it, but do not prove that the substance combined with tannin corresponds to the actual adhesive power of the glue, for it is possible that a glue containing a large quantity of glutin may possess but little adhesive power, and a jelly from which the glue is formed may contain an equal amount of glutin with the latter, but not possess an equal power of adhesion.

It is certain that the determination of the glutin alone is not a criterion of the quality of glue. In the absence of a reliable method of direct analysis, attempts have been made to deduce the quality of glue from indirect properties.

One of these methods consists in immersing the glue

to be tested in a large quantity of water at 12° R. (15° C., 59° F.) for a considerable time. The glue tumefies, absorbing 5 to 16 times its own weight of water. The more consistent and elastic the glue in this state is found to be, the greater its adhesive power, and the larger the quantity of water absorbed the more economical will the glue be in use. This method does not give thoroughly reliable results, and should only be employed with bone glue, as that obtained from animal offal does not behave in a similar manner.

A more reliable method is to test the consistency of a gelatinized glue solution of known concentration at a determined temperature. *Lippowitz* has proposed the following method: After soaking 5 parts of the glue to be tested in water, dissolve it in sufficient hot water to make the weight of the solution equal to 50 parts. To gelatinize the solution keep it at 18° C. (64.4° F.) for 12 hours.

To determine the degree of consistency place the obtained jelly in a cylindrical glass vessel. Place a piece of tin perforated in the centre across the top of the vessel. The hole in the tin should be large enough to allow of the ready passage of a stout iron wire. To the upper end of the wire is soldered a funnel, while the lower end is provided with a saucer-shaped piece of tin with the convex side turned downward and touching the surface of the jelly into which it is forced by loading the funnel with weights.

The greater the consistency of the glue, the greater the weight which will have to be used.

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The following results have been obtained by comparative experiments with this apparatus:—

Variety of Glue.	Weight required to force the saucer down.	
Breslau	1704 grammes	(3.74 lbs.)
Russian	1446 "	(3.18 ")
Cologne	1215 "	(2.67 ")
Muhlhausen I	727 "	(1.599 ")
Nördlingen	724 "	(1.592 ")
Muhlhausen II	387.5 "	(0.85 ")

The following results were obtained by testing glue by the previously mentioned methods:—

Variety of glue.	Loss of water in drying for several hours at 115° to 120° C. (239° to 248° F.)	100 parts of glue are precipitated by tannic acid.	Glutin per cents.	Water absorbed in 24 hours by 5 parts of glue.	A 100 per cent. solution of glue will bear a weight of
1. Best white isinglass in three qualities . .	20 to 21	74.62	55.69	—	
2. Translucent yellowish bone glue in tablets and easily soluble	13.2	76.2	56.8	40	64 grammes (2.25 ozs.)
3. Pale yellow glue similar to No. 2 . .	13.0	70.0	52.2	35	60 " (2.11 ")
4. Brown-reddish, brittle in fracture and soluble	10.0	71.0	52.9	12	Does not gelatinize.
5. Clear translucent glue of medium brown color	11.0	71.5	53.3	20	20 grammes (0.705 oz.)
6. Brown yellow glue in thick tablets and possessing but little translucency . . .	12.5	68.0	50.7	27	15 " (0.52 ")
7. Pale brown-yellow glue, readily soluble and elastic before breaking	13.0	66.6	49.7	30	36 " (1.26 ")
8. Pale amber-colored glue with but little translucency	9.5	68.5	51.1	33	60 " (2.11 ")
9. Brown glue, solution turbid . . .	10.0	72.0	53.7	30	50 " (1.76 ")
10. Amber-colored glue, opalizing and readily soluble	9.5	73.0	54.4	35	56 " (1.97 ")
11. Thick tablets of dark-brown glue, solution very turbid	13.5	64.0	47.7	18	23 " (0.81 ")
12. Dark horn-like glue with little translucency	9.0	72.6	54.2	29	12 " (0.42 ")
13. Very translucent glue of a light brown color and very clean solution	13.5	70.0	52.2	30	40 " (1.41 ")
14. Translucent dark-brown glue, giving a very clean solution	15.0	66.0	49.4	25	42 " (1.48 ")

This table shows the following facts :—

1. The percentage of water in the 14 dry varieties of glue examined, varies between 9.0 and 21. The loss of water from isinglass is surprisingly large, especially as it cannot be explained by an artificial admixture of water, since the six varieties examined reabsorbed the same percentage of water from the air. The percentage of water in the other varieties of glue differs but little.

2. The various varieties of glue required different quantities of tannic acid for their precipitation, the amount for 100 parts of glue varying between 66 parts and 76.2, or calculated to percents., between 49.4 and 56.8.

3. Placed in cold water, glue intumesces and absorbs from 12 to 40 parts of water. The behavior of the various varieties differs very much in this respect, and in most of the experiments, with the exception of variety No. 4, the percentage of glutin is in exact proportion to the quantity of water absorbed.

4. The strength of the gelatinized glue varies between 12 grammes (185.18 grains), and 64 grammes (987.67 grains), for a 10 per cent. solution. This property corresponds neither with the absorption of water nor the percentage of glutin.

Variety No. 4, in the table, contains 52 per cent. of glutin, but does not gelatinize, its strength being therefore equal to 0, while variety No. 14, with 49.4 per cent. of glutin, therefore less than No. 4, shows a strength of 42. As no close connection between the

properties mentioned in the table can be recognized, and as the strength and tenacity of glue do not always depend merely upon its amount of glutin, it has been proposed to test it by mechanical rather than chemical means. These consist in estimating the adhesive power of glue from the weight required to tear asunder two pieces of wood glued together and dried. But as the results obtained by this purely practical test, must necessarily vary on account of the impossibility of having the two surfaces of wood always exactly alike, and the uncertainty of applying every time the same quantity of glue, the following method has been devised. It consists in ascertaining the weight of force required to break a given bar of the material as compared with that used to break a specimen of known quality, which is employed as a standard. To do this with the degree of exactness necessary, sticks of very pure gypsum or plaster-of-Paris are cast of precisely the same dimensions, and then saturated with solutions of different glues, and thoroughly dried. They are placed one by one in a metallic ring having notches, which receive them, and a lever, having the centre of the stick as the resistance, and a graduated mercury cup upon the long arm as the counterpoise. A certain quantity of mercury having been poured into the cup until the stick employed as a standard commences to break, we may take this as the absolute standard, which may be marked 0, and the scale may then be numbered at equal distances above and below. For a glue less tenacious than the

standard, of course a less amount of mercury would be required, and making so many degrees *below zero*, but if a stick saturated with a stronger glue be placed in the apparatus, the mercury would stand *above zero*. The scale might be so graduated as to indicate for every degree of change a glue one per cent. stronger or weaker than the standard.

II.

RAW MATERIALS AND MANNER OF PREPARING THEM FOR THE MANUFACTURE OF GLUE.

The raw materials used for the manufacture of glue consist of a variety of animal offal. The principal substances employed are refuse from the tanyard, such as scraps of ox and other thick hides, the debris of the workshops of leather-dressers, morocco leather manufacturers, etc. The tendons and intestines of many animals, rabbit and hare skins, deprived of their fur, cat and dog skins, scraps of parchment, surons, waste of turners and button makers, and offal from butcher shops and households, help to swell the series of materials used for the manufacture of glue.

The materials are collected and sold either directly to the glue-boiler, or to dealers making a specialty of glue stock.

As a thorough knowledge of these waste products

is of great importance to the manufacturer, we shall devote this chapter to their discussion.

1.—Animal Skin.

Strictly speaking, the skin of animals is composed of two parts, the *corium* or *cutis* and the *cuticle* or *epidermis*. The latter consists of separate and distinct cells, and constitutes the exterior covering in which the wool, fur, or hair of the animal is rooted. It is of no importance to the glue manufacturer. The *corium* or *cutis* is the portion which furnishes the material for glue. Deprived of the epidermis, it is a substance organized of a number of fibres ramifying and intersecting one another in every direction, leaving, however, interstices contracting in size as they reach the outer portion, and which are more or less charged with fluid matter that serves to renew the cuticle and keep the skin pliant and moist. Beneath the corium lies a cellular tissue consisting of fat cells. When it is contaminated, as is frequently the case, with shreds of fat and flesh, it exerts a disturbing influence upon the manufacture of glue.

The tanner trims the skins before steeping them in the ooze. From sheep and calf skins he removes the head portions, it being more advantageous to use them for glue stock. He also cuts off the skin covering the lower part of the thighs, and, to give the skin a neat finish, the ragged edges of the belly part. Of bullock

hides the ears, tails, and foot pieces are utilized for glue stock, while the head parts are tanned.

The refuse of tanning works and scraps of parchment are highly valued as glue stock, since they are in a fit condition for boiling without further preparation.

Of still greater value are the so-called calves' heads, which, after liming and drying, form a special article of commerce.

Skins of hogs, hares, and rabbits yield a light-colored glue of little consistency. It is, therefore, best to use these last-named raw materials for the preparation of glue-water, such as is used in sizing, in the manufacture of paper, etc.

The older the animals from which the skins have been derived, the more solid the glue will be. In many cases, especially where a certain quality of glue is to be produced, it may be recommended to separate the different kinds of skin refuse into lots, provided there is enough of each kind to boil it separately.

To prevent putrefaction, which is always accompanied by decomposition of glue-yielding substance and consequent loss, the scraps must be carefully preserved, especially in summer.

The tanner prepares the refuse by macerating it during fifteen to twenty days in milk of lime, which is frequently renewed. By the action of the lime, adhering particles of blood and flesh are dissolved, and the fatty matter is saponified. After taking the scraps from the lime bath they are spread in the open air to drain and dry. This desiccation is accelerated by

turning them over with a fork several times a day. When sufficiently dry, the materials are packed up and sent to the glue factory.

In case this work is not done carefully in the tan-yard, as is only too frequently the case, the stock is of but little value to the manufacturer.

By allowing the refuse to lie too long in a heap, as is sometimes done, a putrid fermentation sets in, the injurious effects of which cannot be remedied by subsequent liming, or the lime bath has not been strong enough, or has not acted sufficiently long upon the scraps to destroy the adhering particles of blood and flesh. The lime bath, on the other hand, may have been too strong, so as to attack the glue-yielding substance. Frequently it is also the case that the scraps having been dried under unfavorable circumstances, mould has commenced to form, and finally they may be spoiled in winter by allowing them to freeze. Frozen glue leather yields glue of very little consistency.

It will be seen from the foregoing that great precaution and care are required when buying glue-leather. The manufacturer should especially see that it is dry and tough, free from mould and all organic and inorganic substances, and not too strongly limed.

The glue-boiler should, in all cases, be prepared to undertake the preparation of the glue stock himself. The following arrangements are required for the purpose.

We assume that the glue factory is located on a stream of water. In the immediate neighborhood of

the stream a sufficient number of pits to prepare all the glue stock used, each 2 metres (6.56 feet) deep, and 2 to 3 metres (6.56 to 9.84 feet) in diameter, and lined with cement, are so arranged that their bottoms are about 1 metre (3.28 feet) above the level of the water. They are supplied with water by means of a conduit connecting them with each other. Each pit is provided with a discharge pipe for drawing off the dirty water.

As the glue stock, before undergoing other operations, has to be freed from the lime, it is packed in large strong willow baskets, and the latter submerged in the water by means of a travelling crane or other contrivance erected on the bank of the stream. The object is still better accomplished and in a shorter time, by the use of large wash-drums driven by the water itself, such, for instance, as are employed in tanneries for washing hides. They should be so constructed as to allow of their easy filling or emptying without loss or waste. A good plan is to have them rest upon a frame with two wheels, by means of which they can be pushed into the stream after having been filled with 100 to 200 kilogrammes (220 to 440 pounds) of glue stock. One workman, assisted by the water, attends to the revolving of each drum. After washing, the drum is pushed to the drying ground and readily emptied by turning the part with the trap-door downward. The drying ground should, if possible, be in the immediate neighborhood of the pits and in a sunny and airy location, and provided with an in-

clined floor of planks or cement, so arranged as to allow of the admittance of air from beneath.

The glue-stock washer shown in figures 1, 2, 3, and 4 is the invention of Mr. W. A. Hoeveler (American patent), and it relates to the construction of apparatus for washing glue-stock.

In apparatus for this purpose the stock is very commonly damaged by being broken up too much, and considerable loss results, besides, from the fact that the small particles are allowed to escape with the wash-water. By the present construction and arrangement these defects are remedied and other advantages derived.

Fig. 1.

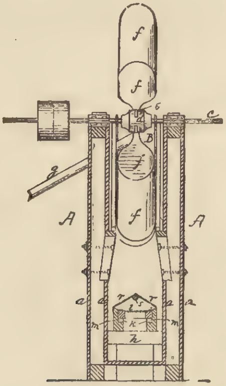


Fig. 1 is a transverse vertical section on line x-x of Fig. 2 of this apparatus ;

Fig. 2 is a longitudinal vertical section of the same;

Fig. 3 is an enlarged plan illustrating the screen and hinged covers, one being open and one closed; and

Fig. 2.

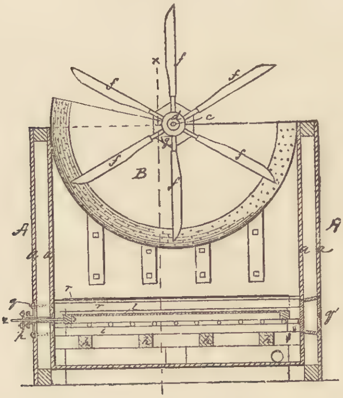


Fig. 3.

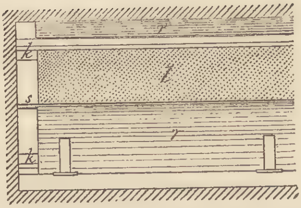
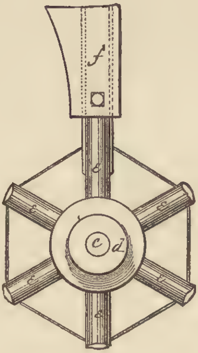


Fig. 4 is a detail of the hub, stems, and part of one paddle.

Fig. 4.



The apparatus is constructed in the form of a rectangular trough-like structure, with its sides and ends, *A*, substantially water-tight by means of the double walls, *a a*. The upper portion of the interior is occupied by the swinging wash-box, *B*, semicircular in shape, with flat sides and rounded bottom throughout, the bottom being perforated.

Upon a transverse shaft, *c*, journaled at the axis of box, *B*, is set a paddle-wheel composed of a suitable hub, *d*, and adjustable paddles, each composed of the radial stem, *e*, and the blade, *f*, or spoon. The spoons, *f*, are set on the stems, *e*, so as to be capable of being reversed or turned half-way round, more or less. One side of the spoon, *f*, is rounded off, so that while passing through the stock the latter will not cling to or remain upon it. The other side of the spoon is flat, but slightly skewed or bevelled, so that when turned to

face with the direction of motion of the wheel it not only gathers up the stock and holds it till out of the box, *B*, but upon further elevation causes it to roll or slide along the paddle to a predetermined point, where it falls off gently into a discharge-spout, *g*, which carries it off for further treatment practically undamaged. During the operation the box *B*, and the body *A*, are kept supplied by a stream of clean or chemically prepared water, and the wheel *e f* revolves slowly in the box, the edges of the paddles sweeping around, while the box *B*, or its bottom is kept oscillating, thus preventing an injurious clogging of the perforations in the box-bottom. After the stock is placed in the box *B*, and the latter filled with sufficient water, the wheel *e f* is caused to slowly revolve (by motive or hand power) with the rounded sides of the spoons *f*, presented forward. This operation thoroughly agitates and cleanses the stock, while the rounded form of the spoons prevents the breaking up of the natural condition of the stock. The inventor gathers the finer particles as follows after they have escaped through the perforated bottom of the wash-box *B*. At the lower part of the trough *A*, elevated on crossbars or blocks *h*, he places two parallel strips, *i*, and between these, which are grooved to form ways, *k*, inside, is set a long screen, *l*, placed on rollers *m*, and movable thereby on the rails or ways *k*. To give movement to the screen *l*, the inventor attaches to its end a rod, *n*, which projects outwardly through the walls, *a a*, by means of the packing-box *p*, and cap or

door *q*, which, when opened, allows the withdrawal of the screen *l*, and its burden. The shaking of the screen is accomplished by a suitable motor applied to rod *n*, and is kept going during the operation, as required. To the strips *i*, which are placed at a little distance from the side walls, *a* (to leave a passage for the water and refuse to go through), are hinged the two doors *r*, which shut down upon the rod *s* as a support, in which case nothing can fall upon the screen, or which open up and rest against the sides *a a*, in which case the screen is exposed and the side passages closed by the doors *r*. During the initial or rough washing stage the doors *r* are kept closed, and the dirty water and refuse pass freely down the side passages and out at a suitable opening at the bottom. After this stage it becomes desirable to catch the particles which get detached from the stock in box *B* and come through the perforations therein. Then open up the doors *r*, thus closing the side passages and compelling all the water and small stock to go to the screen *l*, which catches the remaining stock. When sufficiently accumulated the screen may be drawn out and the stock thereon removed. When the main body of stock in box *B* has been cleansed the paddles or spoons *f* are reversed, so as to present their flat skewed faces to the stock, and in revolving the paddles now gently lift the stock and discharge it into the spout or hopper *g*. The washing and removal of the stock when washed are thus accomplished without further manipulation than to reverse the paddles, which obviously

could be done by a reversing-gear on the motor, thereby reversing the direction of movement of the paddle-wheel.

Instead of the whole box *B* being oscillated back and forth, its bottom may be set on slides or rollers and oscillated, while the sides remain stationary.

In the drawings the box *B* is shown as hung upon the shaft *c* as a centre ; but as the provision of means of reciprocating or oscillating the box or its bottom is within the skill of any machinist, it is not necessary to describe any specific form. As the box with its contents will be very heavy, the inventor prefers a special motor for it, which may also be geared up to reciprocate the screen *l*.

Instead of the door *q*, as located in Fig. 2, it can be located as at *q′*, same figure.

It is, of course, advisable, that the sheds for sorting and storing the glue stock should also be in close proximity, and dry and airy. In the arrangement of the factory, the glue-boiler must, in short, exercise his ingenuity with a view to carrying on the business with as little loss of material, and as much saving of time and labor as possible.

The work in a factory, arranged in the above manner, is carried on as follows:—

The raw materials brought by the dealer are weighed, and if in fresh state, the customary percentage—generally 50 per cent.—taken off. To facilitate future operations, and to enable the manufacturer to produce different varieties of glue, the dry

materials, which are more generally bought, are sorted and stored in different compartments of the store sheds.

Fresh waste, *i. e.*, such as has not been limed and dried, must be prepared at once, as otherwise it would taint the air, be attacked by rats and other vermin, and suffer injurious alterations by decomposition.

The manner of preparing it is as follows:—

Fill the pits with the necessary quantity of water, and dissolve in it 2 per cent. by weight of caustic lime. In order to allow the water to become thoroughly saturated with the lime, let it stand for 8 to 10 days before placing the waste in it. The length of time the latter has to remain in the lime bath varies according to the material, calf-skins requiring 15 to 20 days, sheep-skins, 20 to 30 days, and heavy ox hides, 30 to 40 days. The milk of lime should be renewed once or twice a week, and thoroughly stirred. After removal from the lime pit, the material is placed in willow baskets or nets, and immersed in the stream to remove the greater portion of the lime, which is generally effected in a few days. It is still more effectively accomplished by placing the waste, after soaking in the willow baskets, in the wash drums. After taking it from the baskets or wash drums it is spread in the drying yard to drain and dry, the desiccation being accelerated by turning it over with a fork several times a day. When sufficiently dried, the materials are ready for boiling to glue, and can be stored until wanted.

2.—Bones and Cartilages.

Besides scraps of hides and skin, bones are a material highly valued by the glue-boiler. Bones consist of calcium phosphate, glue-yielding cartilage, fatty matter, and other constituents of no special interest for our purpose. Their value for glue depends very much on the proportional quantities of the substances composing them. By reason of the glue-yielding cartilage predominating in the soft bones of the head, shoulders, ribs, legs, and breast, and especially in buckshorn and the cornillons* of horned animals, they yield a larger quantity of glue than the hard bones of the upper and lower thighs, the thick parts of the vertebra, etc., which are principally composed of calcium phosphate, and have to undergo a special process in order to disintegrate the glue-yielding cartilage. The bones of young animals are richer in glue-yielding substance than those of old.

Bones being less subject to putrefaction than glue leather, they are not brought into commerce in a prepared state, though, before using them for the manufacture of glue, they must be sorted and prepared. In sorting it is recommended to make the following distinctions:—

1. Bones of young animals, sheep, calves, dogs, cats, etc., being readily disintegrated, are thrown into

* The bones occupying the interior of the horns—osseous nucleus.

one pile, and also the light bones of oxen, such as skull bones, shoulder bones, the vertebra of the tail, etc.

2. A second pile is made of the foot bones of goats, sheep, and cattle, provided they can be had, as is the case in the United States and England, in sufficiently large quantities.

3. Scraps and shavings of buckshorn from turners and button-makers.

4. Thick bones of oxen, horses, etc., which must remain longer in the lime-bath, together with waste of hard bones from turners.

5. Where large quantities of bones are handled, it is advisable to sort out the bones of the upper thigh, as they can be more advantageously used for the manufacture of piano keys, handles for tooth brushes, etc. Hoofs and horns, which are frequently found, should be thrown out, as they yield no glue and can be utilized for other purposes.

After sorting, the bones are ground or crushed in a mill. The object of this operation is to facilitate the removal of the fatty matter, and accelerate the action of the lime-bath, in which the comminuted bones are placed later on.

After comminuting, the bones are put in a large boiler and subjected to the action of steam for a few hours. Foot bones, buckshorn, and cornillons should not be boiled, as they contain no fat, and would lose too much glue-yielding substance. After boiling, the bones are placed in a lime-vat for 8 to 14 days. The

water used for boiling the first portion of bones may be used for a second.

The extracted fat, amounting to 4 or 5 per cent. of the quantity of bones used, is taken off the surface of the cold liquor, and the latter used as a manure, or is given to cattle as a fodder.

The lime-bath used should be of the same strength as that for scraps of hide. After removal from the lime-vat and washing, the bones are put in a tank of stone or wood (brick pits should not be used), and a mixture of hydrochloric acid and a quantity of water to reduce the mixture to 7° B. (1.05 specific gravity, 10.6 per cent. Cl. H.) for thick bones, and $3\frac{1}{2}$° B. for thin ones, is poured over them so as to cover them completely. 10 kilogr. (22 lbs.) of bones require about 40 litres (10.56 gallons) of the mixture. The tank is covered close with a wooden lid, and the bones are thus left to macerate for 8 to 14 days, being frequently stirred and fresh acid added. By the action of the acid the calcium phosphate is dissolved and readily soluble calcium hydrochlorate formed, while phosphoric acid is liberated and retained in the liquor. When sufficiently softened the bones are placed in willow-baskets and immersed in running water for about one hour to remove the greater portion of the acid. They are then thrown into a bath of weak lime-water, where they are left to steep one day; they are then removed, washed with fresh water for the purpose of removing the acid which may have penetrated them, and then

either dried and stored away for future use, or boiled at once to glue while in a moist state.

Foot bones, buckshorn, and other soft bones containing scarcely any fatty matter, though not boiled for the reason previously stated, are treated in all other respects like boiled bones.

It is of the greatest importance that the bones should be thoroughly freed from acid, since even the smallest quantity remaining behind exerts an injurious effect upon the finished glue. It is therefore recommended to test the water draining off, or the bones themselves with litmus. If the tincture turns red, it is a sure indication of the presence of free acid, and the washing must be continued until the blue color of the tincture remains constant.

Gerland's suggestion to use dilute sulphurous acid instead of hydrochloric acid for dissolving the phosphates of the bones, and to evaporate the sulphurous acid by heating, whereby the phosphates are precipitated in an insoluble state, deserves mention, though in our opinion it is scarcely available for working on a large scale.

Bones honeycombed by putrefaction, exposure to the weather, or burial in the ground are of little or no value to the glue-boiler, as nearly all the glue-yielding substance has been destroyed, and should therefore be thrown out in buying stock.

3.—Leather Waste.

Leather tanned with a substance insoluble in water is not directly suitable for manufacturing glue, but can be made so by a special process, which, though somewhat tedious, nevertheless pays for the trouble.

In using such stock the manufacturer should make a distinction between old and new leather. The principal materials of this kind, large quantities of which contribute their quota to the glue-boiler's stock, are old shoes, straps, harness, etc., and further, waste from shoemakers, trunkmakers, and in fact from the shops of all workers in leather except those using alumed leather.

Before boiling the leather waste to glue, the removal of all traces of tannic acid becomes absolutely necessary, since the retention of the smallest quantity prevents the animal tissue from dissolving in water.

The various methods proposed for the preparation of the leather waste differ either in the chemical solvent used, or in the mechanical manipulation of the waste.

The principal point in all methods is to comminute the waste as uniformly as possible to facilitate the complete removal of the tannic acid.

Various machines, some very complicated, have been proposed for the comminution of the waste, but according to our experience, a half-stuff hollander, such as is used in paper factories, is the best for the purpose, as it not only comminutes, washes, and pre-

pares the waste in a suitable manner for the manufacture of glue, but the leather pulp mixed with rags or woody fibre gives a substitute for leather which is very tough and of good appearance, and can be worked into many articles.

After the preparation in the hollander and careful washing the waste is treated, according to *Stenhousé*, under a pressure of two atmospheres in a boiler with water to which is added 15 per cent. of the quantity of waste to be treated at one time of slacked lime.

By another method the extraction of the tannic acid is effected by boiling the leather pulp with caustic soda for from six to twelve hours.

After drawing off the water and pressing out, the pulp is again boiled with caustic soda of the same concentration. The next process is to carefully wash out the soda, which is best effected in the hollander.

By neutralizing the soda lye in the fluid drawn off after the first boiling, it can be re-used for tanning or purposes for which tannic acid is required.

According to another method, the *modus operandi* is as follows:—

Dissolve 1½ lbs. of oxalic acid in 12 litres (3.17 gallons) of water, pour the boiling solution over 50 kilogr. (110 lbs.) of waste, and keep the mixture in a water-bath at a temperature of 80° to 100° C. (176° to 212° F.). This effects the solution of the pulp. Then dilute the solution by adding gradually 15 litres (3.96 gallons) of water until a uniform mass is formed. Now add 5 lbs. of lime slacked to a thin paste, and

mix the whole thoroughly. The mass becomes friable and pulverulent. It is passed through a wire sieve and then exposed to the air. In three to four weeks the tannic acid is entirely destroyed, which is recognized by the mass assuming a lighter color. The lime is then removed by washing with water and hydrochloric acid. If the tannic acid has not been entirely destroyed by exposure to the air, add 0.5 kilog. (1.1 lb.) of aqua ammonia and a like quantity of pyrolusite to every 50 kilogr. (110 lbs.) of leather substance when boiling it to glue. The oxygen yielded up by the pyrolusite, which, in the presence of ammonia, exerts no injurious effect upon the glue, destroys the last traces of tannic acid. Frequent stirring with a shovel while the material is exposed to the air and moderate heating facilitate the destruction of the tannic acid.

4.—Raw Materials for Fish-Glue.

The air-bladders or sounds of various fishes contain much glue substance, which, on account of its purity, is preferably used for culinary and medicinal purposes. The high price of this raw material excludes it from being used by the glue-boiler, but as he manufactures substitutes for isinglass, and should therefore have a thorough knowledge of the article with which he has to compete, we include both isinglass and fish-glue in our treatise.

Isinglass being a specialty, we will later on speak

of the sources from which it is derived, and the manner of preparing it.

There is a material difference between isinglass and glue manufactured from entire fishes. This raw material is, of course, limited to certain localities. The principal point to be observed in the manufacture of fish-glue is the removal of the skin, which is effected by means of dilute sulphuric acid.

After removal of the last traces of acid, the fatty matter of the fishes is saponified by a treatment with milk of lime frequently renewed. After washing out the lime, the pulpy mass is placed in a solution of sodium hyposulphite, alum, and common salt, where it remains for a few days. The liquor is then drawn off and replaced by a mixture of solution of alum, dilute sulphuric acid, and nitric acid. After macerating in this mixture for a few days, the mass is thoroughly washed and boiled to glue, and the resulting product clarified with sulphurous acid or alum solution. As will be seen, the entire process is tedious, requires many chemicals, and besides the yield of glue, which has no specially good qualities, is small. It is used as a substitute for isinglass for clarifying liquids. The best proof that the business is of but little importance, is found in the fact that no fish-glue has been exhibited at any of the late international exhibitions.

The scales of large fishes, such as carp, give more favorable results. They are treated with hydrochloric acid in a similar manner to bones. The scales do not

dissolve entirely, a horny insoluble mass, giving no glue, remaining behind after the solution of the glue-yielding substance.

III.

FABRICATION OF GLUE.

After a thorough preparation of the raw materials, which will materially facilitate all succeeding processes, and make success more assured, the following operations are performed.

1.—Boiling Glue.

For the operation a boiler of cast-iron, sheet-iron, or best of copper is used. Its size depends on the quantity of raw material to be worked at one time. It is best to choose boilers holding from 50 to 200 kilogrammes (110 to 440 lbs.) of raw material, and to place two, four, or more of such boilers in one hearth, in such a manner that their bottoms, which converge inwardly, the better to resist the heat, are equally exposed to the flame. Resting upon the bottom is a stop-cock for the evacuation of the gelatinous solution. About 0.02 meter to 0.10 meter (.787 in. to 3.94 in.) above the true bottom there is another false bottom, perforated and movable. It is supported by flanges or tripods, 10 to 12 centimeters (3.93 to 4.72 inches)

high, and serves as a preventive of direct contact of the materials with the heated bottom of the boiler, and consequently of any injury by scorching. In the centre of the false bottom stands a conical pipe 0.6 to 1 meter (1.97 to 3.28 feet) high, pierced with holes, and communicating with the space between the true and the false bottoms.

The height of the boiler can be increased 0.3 to 0.4 meter (0.98 to 1.31 feet), by placing an annular piece upon the rim, which is bent upwards for its reception.

The manner of using such a boiler is very simple. Straw is placed upon the false bottom in such a manner as to cover its entire surface, and extend up the sides of the boiler at least as far as it is touched by the flame. The object of the straw is to serve as a filter, and protect the materials from injury by the flame. But for the production of entirely pure gelatin or glue, straw cannot be used, as, by boiling, it yields a yellow coloring matter, which passes into the glue. Barley straw gives a less intense coloring matter than rye straw.

Where straw cannot be used, the material is placed in a wide-mouthed bag or net made of rope, and spread open in the boiler which contains a light iron framing to prevent the bag adhering to the sides or bottom. The boiler, being heaped with material so high as to overflow the brim and fill the annular piece placed upon it, is then filled with water as far as touched by the fire. The hearth in which the boiler is placed

should, of course, be so constructed, that the gases are uniformly distributed and the water quickly brought to the boiling point.

As soon as ebullition commences, bubbles of steam ascend from the space beneath the false bottom, and passing through the holes of the conical pipe penetrate the glue substance. In consequence of ebullition the first formation of glue takes place, and the materials begin to settle down gradually, until at last they become completely submerged in the liquid, which has proportionally augmented in volume.

Scraps of hide and cornillons are completely dissolved in five to seven hours. No more water should be used than is absolutely required to bring the entire quantity of materials to ebullition, because too much water renders the solution too thin and gives a jelly of little consistency and difficult to dry. Concentrating the glue by continued boiling, as is frequently done, injures it by reason of the glutin undergoing a gradual transformation. Frequent and thorough stirring is indispensable during the ebullition, but care should be had not to disarrange the straw upon the false bottom and on the sides of the boiler, as this would interfere with proper filtration. It is also advisable to start with a slow fire in order to give the materials time for softening and thus prepare them for solution. After the glue-yielding substances have been somewhat softened, the entire mass is brought to ebullition, which should be gentle and uniform and kept up until the entire mass is dissolved.

The duration of boiling depends on the nature of the raw materials. Scraps of skin from young animals, antlers, sheep trotters, etc., dissolve in three to four hours, while refuse from ox and horse hides, or bones from old animals, require six to eight hours.

The progress of the operation is readily ascertained by pouring a small sample of the gelatinous fluid in half an eggshell, and setting it aside for a few minutes to cool. If a clear and consistent jelly be obtained, the boiling has been carried to a sufficient extent, and the liquid is drawn off. Any undissolved glue stock remaining upon the straw filter can be boiled by itself, and the resulting gelatinous liquor utilized in the next boiling.

It is self-evident that a quick and uniform melting of the materials, which enhances the quality of the glue, is promoted by comminuting the glue stock either by grinding, stamping, or mechanical means.

The succeeding clarification of the glue is much facilitated by removing during the ebullition the scum, consisting of fat, coagulated albumen, lime-soap, accidental admixtures, and other impurities. Before drawing off the gelatinous liquor it is advisable to withdraw the fire and allow the contents of the boiler to rest for fifteen minutes.

The residue remaining upon the straw filter consists of hair, lime-soap, undissolved particles of hide and bones, lime, etc., and is utilized, after repeated boiling, to obtain the remaining gelatin, as manure, or for the manufacture of gas to be used in the factory.

The mode of glue-boiling above described is the oldest and at present the only one in use in small establishments. In larger ones it has been superseded by the more rational process of dissolving the materials in slightly conical vats of wrought iron or wood lined with metal, heated by the introduction of steam through a wrought-iron pipe reposing upon the bottom. The vats are twice as high as they are wide, and capable of resisting a pressure of two atmospheres. At some distance above the true bottom there is another false bottom perforated and movable. The cleansed materials are thrown into the vats through a charging hole and the latter hermetically closed. The steam, which is then admitted, exerts at once a dissolving influence upon the materials. A part of the steam condenses and forms with the dissolved glue stock a concentrated jelly, which collects between the true and the false bottoms. The uncondensed steam escapes through a pipe placed below the charging hole.

The advantages of this process are obvious. A larger quantity of glue stock can be dissolved than in a boiler, and there is no danger of injury by scorching, and consequent damage to the color of the glue. More highly concentrated solutions are obtained in a shorter time, and the spoiling of the glue by too long continued boiling is prevented by drawing off the gelatinous liquid as quickly as formed. The escaping hot steam is utilized for drying the glue, soaking the raw materials, etc. A further great advantage of this

method is that there is less annoyance from badly smelling vapors.

A system of such vats can be arranged in one room and fed by one boiler.

2.—Classification of Glue.

The clearness of glue, *i. e.*, its freedom from undissolved substances, is by no means a criterion of its value as an agglutinant, since pulverulent inorganic substances (white lead) are frequently intentionally introduced into some varieties, for instance into Russian glue, without injury to their adhesive power. But as a turbid appearance may also be an indication of unsoundness and decomposition, the manufacturer endeavors by all means to obtain a clear product.

A strict distinction should be made between clearness and color. Very dark-colored glue may be very clear, and a very pale variety the reverse, yet both possess excellent qualities. Both properties, clearness and light color, cannot be obtained by the same process.

We shall first speak of clearness.

If the glue stock has been properly prepared by rendering adhering particles of blood and fat innoxious by liming and subsequent careful washing, the separation of the few remaining impurities, which may have passed through the straw filter, is readily effected by allowing the gelatinous solution to stand, care being had to keep it liquid as long as possible to give the

solid particles sufficient time to settle. This is best effected in a wooden vat lined with sheet iron and enveloped in some material a non-conductor of heat, such as hair, sawdust, chopped straw, etc. After the solid particles have settled, the supernatant gelatinous fluid is drawn off through a discharge pipe placed a few centimeters above the bottom of the vat.

Should this mechanical separation not prove sufficient, recourse must be had to chemical means, and 0.5 kilogr. (1.1 lb.) of pulverized alum or sulphate of alumina added to every 600 cubic centimeters (20.3 fluidozs.) of gelatinous solution in the clarifying vat. Either of these chemicals removes the albuminous and extractive constituents of the gelatinous solution, and converts the dissolved free lime into sulphate of lime, which settles readily, and prevents putrefaction of the glue while drying under unfavorable circumstances. The quantity of alum mentioned does not impair the quality of the glue.

The precipitation of the lime might be better effected by oxalic acid, and the organic substances removed as scum by adding to the boiling mass some astringent matter, such as a decoction of oak bark or hops; but the purification has, in either case, to be done at the expense of glutin.

A gelatinous solution, which is not clarified by these means, is not sound, and is derived either from spoiled raw materials, or such as have not been thoroughly prepared, or has been injured in boiling.

A far more difficult matter than the removal of

mechanical admixtures is to free the gelatinous solutions from the coloring substances, from which it derives its color, and to discolor it without injury to the characteristic qualities of the glue.

The use of animal charcoal for such large quantities of somewhat thickly-fluid solutions, which are liable to spoil at the high temperature at which they would have to be filtered, is very difficult, and the result not favorable, except the solutions could be successfully deprived of their tendency to putrefy. Phenylacetic acid has been proposed for this purpose. We are unable to say whether it is available for working on a large scale, but in any case the filtration of gelatinous solution through animal charcoal presents difficulties which can scarcely be overcome.

The object is more easily effected by bleaching the raw materials previous to boiling them to glue.

This is accomplished by placing the glue stock, thoroughly limed and while still moist, in a bath of chloride of lime, not too strong, as otherwise the solution of the materials becomes difficult. A bath of the proper concentration is made by dissolving 0.25 kilogr. (8.81 ozs.) of chloride of lime in sufficient water to cover 50 kilogr. (110 lbs.) of glue stock. After one hour add sufficient hydrochloric acid to obtain an acid reaction, which is recognized by litmus paper dipped in the bath turning red.

Although the glue stock is not bleached entirely through by this process, the thin portions and outsides of the thick material acquire a light color, and the

first running of gelatinous solution will have a light color, and can then be treated further without much difficulty.

Sulphurous acid has been successfully used for the production of entirely colorless glue without the necessity of boiling.

Place scraps of hide and skin (the only available material for this process) in water until putrefaction sets in. When this is the case, wash the material in a wide-mouthed bag or willow basket in running water. Then pour $2\frac{1}{2}$ parts of sulphurous acid over 12 parts of wet material, mix the whole thoroughly, and let it stand in a hermetically closed vessel for 24 hours. Now draw off the acid, and after washing the material thoroughly, repeat the operation. When the vessel containing the mixture of material and sulphurous acid is opened for the second time, the foul odor should be entirely superseded by that of sulphurous acid; this being a sure indication of the correct execution of the process. Wash the material, and, after squeezing, throw it into a vat large enough not to be filled by it more than two-thirds full. After filling the vat with water, allow the mass to digest at a temperature of 43° C. (109.4° F.) for 24 hours. The result will be a gelatinous solution, which is drawn off and converted into glue. The undissolved residue is transformed into gelatinous solution by pouring water over it and allowing it to stand at a somewhat higher temperature.

For carrying out this process and that of bleaching

with chloride of lime, it is best to use a vat provided with a stirring apparatus somewhat like a hollander used in paper factories, as being most suitable for washing the materials, separating the fibre, and mixing.

3.—Moulding the Glue.

After clarifying, the gelatinous solution is run into moulds of deal wood or sheet iron, lightly joined and of a rectangular form, slightly converging towards the bottom so as to allow the more ready detachment of their contents. They are about 1 meter (3.28 feet) long, 0.25 meter (0.82 foot) wide at the top, and 0.20 meter (0.65 foot) at the bottom, and 0.15 meter (0.49 foot) deep. When very regular cakes of glue are desired, cross grooves of the required shape are cut in the bottoms. After being well cleansed and ranged upon a level the boxes are filled to the brim through large funnels with strainer cloths affixed to their barrels. It is best to place them upon perfectly clean stone flagging slightly inclined towards a reservoir for the reception of such portions of their contents as may run over. The apartment in which the work is performed should be clean and airy, a dry cellar being the best for the purpose. In place of a large number of boxes, a shallow vessel lined with sheet iron and capable of holding the entire quantity of gelatinous solution is sometimes used, from which the solid jelly is cut out in cubic masses, which are further divided.

This arrangement can only be recommended for

establishments where but one variety of glue is produced, and the different layers in the clarifying vat are not separated according to their clearness. Before pouring the gelatinous solution into the boxes the latter should be moistened with water or coated with oil, stearine, or paraffin to prevent the solution from penetrating the wood and the solidifying glue from adhering to the sides.

After the solidification of the glue, which generally takes place in twelve to eighteen hours, the boxes are inverted upon a table with a smooth top of wood or stone previously wetted, so as to prevent the adherence of the gelatinous cake to its surface. To detach it from the sides of the boxes the moistened blade of a large knife is generally used.

Cutting the cubes of glue into commercial cakes or slabs is readily accomplished by observing the following instructions:—

The shape of the slab depends principally on custom. The consumer is used to a certain variety of glue, and if it is not offered to him in the customary shape, he might refuse it and take his custom elsewhere. The quality of the glue is the next point to be considered. If very dark, it is advisable to cut the glue into thin slabs, and if turbid, into thick ones, in order to make this defect the less apparent. Thicker slabs can also be cut if the conditions for drying them are favorable, and thinner ones if the reverse is the case.

The mass is first divided by a steel or brass wire stretched over a frame, like a bow saw, into horizontal

layers. The size of these layers is regulated by guides which are placed at distances corresponding with the desired thickness of the slab of glue. Instead of one wire, as many as slabs of glue are to be cut, can be stretched over the frame, which is best made of iron and provided with conical pins by means of which the wires can be tightened, in the same manner as piano strings, when they have become slack by use.

The width and thickness of the cakes of glue are regulated by the distance of the wires from each other, and the length by the width of the box. The cakes thus formed are dexterously lifted from the block with the moist blade of a large knife and placed upon nets.

4.—Drying the Glue.

The drying of the glue is without doubt the most precarious part of the manufacture. The jelly contains a large quantity of water, which, to prevent decomposition of the jelly before it is converted into glue, must be evaporated as quickly as possible. In favorable weather the drying can be accomplished either in the open air or in covered sheds.

Drying in the open air is connected with many inconveniences, for if the sun strikes the cakes of jelly when they still contain a large quantity of water, they may become soft so as to run through the meshes of the net, or they may dry so quickly as to prevent them from contracting to their proper size, without numerous cracks and fissures. If frost supervenes,

numerous cracks may be formed in the cakes from the congelation of their water, or a shower of rain may cause much work and damage. In consideration of all these inconveniences, it is best to conduct the operation in a drying-room.

To insure a constant circulation of air, which is absolutely necessary for the expulsion of the aqueous vapor caused by the evaporation of such a large quantity of water, the drying-room should be at least 3 meters (9.84 feet) high, even if intended for summer use only, and the windows be provided with Venetian blinds so as to shut out the sun, if necessary, without disturbing the circulation of air.

To dry the cakes in heated rooms in winter is a more difficult matter, as provision has to be made for the removal of the aqueous vapor, and a current of warm dry air has to be kept up at the same time. But such a room is an absolute necessity for the manufacturer on a large scale who, in order to carry on his business without interruption throughout the entire year, must be independent of the changes of wind and weather.

The size of the drying-room should be proportional to the daily production. Recent constructions are fitted up with the requisite frames for the reception of the glue cakes, and are heated by steam pipes arranged along the walls. In the floor in the immediate neighborhood of the steam pipes are openings, which can be opened and shut at pleasure, for the admission of fresh dry air. The latter on entering the room

is heated, and after passing over the frames and absorbing water from the glue cakes, escapes through openings in the ceiling to a space above it from which it is withdrawn by means of ventilators in the roof. A constant change of air must be kept up. The quick drying of the glue is of the utmost importance, as otherwise the jelly putrefies either entirely or partly, and the glue acquires a turbid and mean appearance. Too much heat causes the cakes to bend and crack. The cakes are placed upon wide-meshed nets of pack thread stretched upon frames 2 to 2½ meters (6.56 to 8.2 feet) long and 1 meter (3.28 feet) wide. The frames are set over each other at distances of about 0.3 meter (0.98 foot), being supported by small wooden pegs stuck into mortise holes in the uprights arranged around the room in the neighborhood of the steam pipes and air flues. The cakes must, moreover, be turned upside down upon the nets twice or three times every day, which is readily managed, as each frame may be slid out like a drawer upon the pegs at its two sides.

The temperature of the drying-room requires careful regulation, and should never be allowed to rise above 20° to 25° C. (68° to 77° F.), as otherwise the glue would soften and run through the meshes of the net, or adhere so firmly to the twine as to require the nets to be put in hot water for its separation. Dryness of air is of far greater importance in the drying process than a high temperature. To promote this dryness of air and prevent the aqueous vapor from condensing, evaporating, and again condensing upon the cold walls

of the room, they are wainscoted. Thus protected by a bad conductor, they acquire a higher temperature, and the aqueous vapor, instead of being precipitated upon them, is carried off by the air-currents.

As the cakes placed in the immediate neighborhood of the steam pipes and near the floor where the dry air enters, dry quickest, the nets containing them are shifted after some time to a higher part of the drying-room and their former places filled with cakes still wet. When the cakes are dry, they are finally desiccated in a room at a higher temperature, which serves to harden and improve them.

To expel all moisture from the air previous to its entering the drying-room, it has been proposed to conduct it through concentrated sulphuric acid or calcium chloride.

The removal of water from the jelly being such a difficult matter, an endeavor should be made to obtain solutions of a high degree of concentration.

In the following we give a description of an apparatus for drying glue, etc., which is the invention of W. A. Hoeveller.

Fig. 5 is a plan section, and Fig. 6 a side elevation in section, of this improved drying-alley. Fig. 7 is an end view in section.

The form and arrangement are as follows:—

A B represent the two parts of the alley, separated by the partition *C*, which is shorter than the alley, so as to leave a communicating space at both ends.

At the front of section *A*, is located a blower, *D*,

actuated by a steam-engine or other motor, *E*, also located within the walls of the alley. The whole current from blower *D*, is directed through section *A* of

Fig. 5.

Fig. 6.

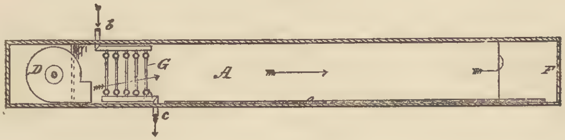
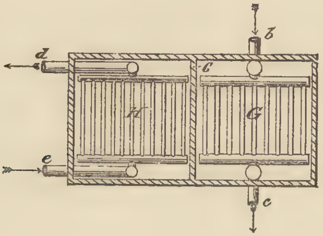


Fig. 7.



the alley, whence it turns into section *B*, and comes back through it, to be again drawn into and forced out of the blower into section *A*. By this means the contained air of the alley is set in continuous motion

through the two sections successively, and as the structure is made as air-tight as practicable in such cases, the air remains unchanged until the doors *F*, or either of them, are opened to discharge the vitiated air and let in the fresh.

In sections *A* and *B*, is placed the railway *a a*, to admit of the convenient movement of the contents in process of drying, which are generally set on cars or buggies.

In section *A*, in front of blower *D*, is placed a steam or other heating device, *G*, which may be of any form or design adapted to allow the air from blower *D* to pass through it and to heat such air while passing therethrough. The inventor prefers the radiating coil for such purpose, the steam entering at *b*, and emerging at *c*. At the other end of the alley, which by the double construction is in section *B*, just back of the blower and heating-coil, there is placed a condensing-coil, *H*, of a construction similar to coil *G*, and having inlet *d*, and outlet *e*. Through this condenser there is kept flowing a refrigerating liquid or brine, which renders the condenser very cold. The continuous current of air from the blower passes over the contents of the cars or trays in the alley and takes up moisture in its passage. After such passage the air is charged with moisture and comes in contact with the coils of the condenser *H*, upon which the charge of moisture is condensed, and the air emerges dry again, enters the blower, and is again made the vehicle by

which the moisture of the glue or other contents is transported to and deposited on the condenser.

In drying glue by this method do not use the steam-coil at the first stage of drying a charge, as the drying should not be effected too rapidly; but as soon as the product begins to stiffen properly, admit the steam to coil *G*, and thereafter the operation is continuous, as above described.

By doubling up the alley into two sections, as shown, the inventor is enabled to erect the alley in a more contracted space. In a length of ninety feet he obtains the benefit of a single alley one hundred and eighty feet long. Section *B* may, if desired, be located on top of section *A*. Doors may be located wherever desired, to facilitate the movement of the trays or cars and the placing of them into and their removal from the alley.

By the above apparatus the drying can be perfected in a very much shorter time than can be done by the old alleys, and operations can be conducted in hot weather without hinderance from the condition of the atmosphere.

In cases where the atmosphere is dry enough to dispense with the heater and the condenser, the inventor can throw the doors *F* wide open, extend the partition *C* out to that end of the alley, and then preserve a continuous forced draft of sufficiently dry air in both alleys for the purpose. As there are many days during the year fine enough to give reasonably dry air, operations can be conducted with the blower alone in

this way, and thus economize the steam and the refrigerating-brine.

A process, which deserves attention, is to make use of the water-absorbing power of some salts, such as Epsom and Glauber's salt, for the purpose of withdrawing water from the gelatinous cakes. For a practical application of this principle on a large scale, a wooden box with low sides is required. The bottom of the box is sprinkled with a layer of sulphate of ammonia, Epsom or Glauber's salt about half an inch in depth, and a moist linen cloth laid over ; upon this is placed a layer of jelly which is covered with a moist linen cloth, and thus the alternation is continued until the box is full, after which it is left for some hours and the liquefied solution allowed to drain off through a hole in the bottom, the dropping ceasing in from twelve to eighteen hours. If, now, the upper cloth is taken off with its layer of salt, the glue beneath it will be found so far deprived of its moisture, that, when placed in the sun or exposed to other heat, it will become completely dry in a short time without either melting or spoiling, and in winter may be laid upon drying floors with the same results.

This method has its defects as well as advantages. Among the former may be enumerated a slight want of transparency caused by the salt used in the process, and the taking up of from 3 to 6 per cent. of salt. The advantages, on the other hand, are in rendering the manufacture independent of climate and vicissitudes of weather, and capable of being prosecuted at any

season of the year, and the fact that the salt can be used over and over again with scarcely any loss.

The following plan seems to us still more suitable. The gelatinous solution, as concentrated as possible, is kept liquid at a uniform low temperature in a wide shallow boiler, on the rim of which a sheet-iron roller of large circumference is placed so as to dip into the solution. The roller is moderately heated by steam, and in revolving carries with it a thin layer of the gelatinous solution, which, before the roller has finished an entire revolution, will be sufficiently desiccated so that it can be taken off, and, after cutting into cakes, placed upon nets to dry. The roller can also be used for the concentration of a weak solution by scraping off the adhering layer and returning it to the boiler. By repeating this several times the solution will be sufficiently concentrated to allow the employment of the roller for its proper purpose.

The surfaces of the cakes become mouldy and soiled in drying, and it is therefore necessary, in order to give them the good appearance and lustre required of commercial glue, to scour them with a brush dipped in warm water, and replace them upon the nets to dry.

IV.

PLAN AND ARRANGEMENT OF A GLUE FACTORY.

a.—Description of the Required Plant and Utensils.

A convenient location and well-planned arrangement of the factory are the principal requisites for the success of the enterprise. Errors committed in these particulars cannot be rectified even by the most careful and skilled management. We know of factories which pay thousands of dollars every year for transportation which could have been saved if proper circumspection had been used in the choice of location. An inconvenient arrangement of the establishment or a badly working machine frequently causes more loss in one year than would pay for an entire rearrangement.

Large establishments are but seldom planned and arranged as such, but generally grow up gradually from small beginnings, and as few would be willing to pull down what has cost so much labor and expense to erect, and to rearrange the entire establishment, it is well to make the first plan with a view of a future expansion of the business.

1.—Choice of Location.

As few neighborhoods are willing to submit to the erection of a glue factory in their midst, the manufacturer, in his selection of a location, is limited in most cities and boroughs by stringent laws and ordinances. Generally speaking, this is the fault of the glue-boilers themselves, because they take no pains whatever to avoid stench and consequent poisoning of the air. A glue factory kept scrupulously clean, and where putrefaction of raw material, which besides is always a loss to the manufacturer, is strictly avoided, and provision made for burning the bad smelling vapors and gases, need scarcely cause as much inconvenience to the neighborhood as well-conducted slaughter-houses, soap-boiling establishments, etc., which are tolerated almost everywhere, even in thickly populated parts of cities.

With the assistance of science and technics, the operations of factories in which the excrements of the population of large cities are worked into poudrette, have been rendered inodorous and consequently harmless to the surrounding neighborhood; and how much easier would it be to attain the same results as regards glue-boiling. Instead of hampering the glue-boiler in the choice of location, and banishing him to out of the way places where labor is difficult to obtain and the conditions of transport unfavorable, it would be wiser for the lawmakers to enact and enforce such laws as would compel the manufacturer to make the

necessary provisions for the protection of his workmen and the neighborhood.

The cost of transportation, being a considerable item, must be carefully considered in the choice of a location. If, for instance, 1,000,000 kilogr. (2,200,000 lbs.) of raw material, and 500,000 kilogr. (1,100,000 lbs.) of finished product have to be transported every year, and but a few cents be saved on every 100 kilogr. (220 lbs.), it will amount to a sufficiently large sum to be worthy of consideration.

It may, of course, be the case that a factory can procure all the raw materials from tanneries and slaughter-houses in its immediate neighborhood or from a large city, but as these favorable conditions are liable to be changed by competition or other circumstances, it is well to consider the possibility of having to procure the materials from a distance, and to select a location near a railroad or a navigable river, the latter being the most advantageous on account of the large quantity of running water required in the mechanical operations. The neighborhood of one or more large cities will always be favorable for the procurement of cheap materials, though some large factories working, almost exclusively, bones imported from *Russia* and *South America*, compete successfully at the present time with such as obtain their materials from the immediate neighborhood.

There are other points to be taken into consideration, such as taxes, competition with other factories

already established, a suitable market for the product manufactured, etc., but as they vary so much under different circumstances, we cannot enter into details, but proceed at once to the

2.—Arrangement of the Factory.

While the choice of a proper location has, we might say, to be invented for every special case, the suitable arrangement of the factory is less difficult, as in this respect we can be guided by model establishments already in existence. The work to be done can be divided into three principal operations: Preparing the raw material, boiling the crude glue to jelly, and converting the jelly into glue. These operations have to be carried on not only at different times, but also in separate rooms.

For preparing the raw materials, glue-pieces, bones, etc., are required:

1. A large shed for storing and sorting. It should be as airy as possible, and provided with a floor, and, along the walls, with bins of sufficient size to hold the different kinds of raw material. Its size will, of course, depend principally on the extent of the business and the facilities for converting the raw materials into crude glue. To prevent putrefaction and consequent loss, and also annoyance to the neighborhood, the latter work should be done, especially in summer, as soon as possible after the reception of the materials.

A suitable and convenient arrangement of the lime

and acid vats is of great importance. They should be about 2 to 2.5 meters (6.56 to 8.2 feet) deep, and placed in close proximity to the store-shed, best under its projecting roof, and as near as possible to a stream of running water. Their edges should be low enough to allow of the direct dumping of the materials into them from a wheelbarrow. This is best accomplished by throwing up an embankment, and setting the tanks in this with their edges level with the ground and their bottoms about 1 meter (3.28 feet) above the surface of the water. Such an arrangement will materially facilitate the filling and emptying of the vats.

The lime vats are best constructed of hard-burned bricks laid in cement and plastered with a thick coat of the same material. The coping should consist of large hewn stone. The acid vats can be made of stone plates (gneiss, mica, slate, or sandstone) or of deal wood, and should be of the same size as the lime vats.

To save transporting the material a great distance it is recommended to arrange the lime and acid vats in alternation. They are filled with water by a channel connecting them with each other.

Suitable arrangements must be provided for the thorough washing of the materials after liming and treating with acid.

We have already referred to this in Chapter II., and will here only add that a quick and convenient method of emptying the vats is to have for every two of them an upright provided with a pulley over which

runs a rope by means of which the wicker-baskets or perforated wooden or sheet-iron boxes containing the limed materials are submerged in the water and raised later on. Small wheels attached to the baskets or boxes will facilitate their transport to the drying place.

Bones have to be comminuted before extracting the fat, and as the latter work has to be done before liming and treating with acid, it is recommended to locate the machinery required for these purposes in close proximity to the above-described arrangements.

The bones are comminuted with an iron stamper or crushed between a run of millstones, which answers the purpose better, and besides there is less danger of the materials becoming heated, which imparts to the gelatine an empyreumatic odor. The boiler, in which the comminuted bones coming from the mill are boiled for a short time, and the mill should be located in the neighborhood of the store-shed and be connected with it. If an extracting apparatus for bisulphide of carbon is used instead of a boiler, it takes the place of the latter. Large wooden boxes, from which the air is exhausted, can be used in place of the acid vats, but in this case the arrangement has to be altered so as to locate the boxes as closely as possible to the motive power by means of which the exhaustion of the air from the boxes and bones is effected.

The hollander used for the various operations of mixing and washing, especially in working scraps of tanned leather, can be located in the room with the crushing mill and the apparatus for extracting the fat.

The bones after comminuting, extracting the fat, liming, treating with acid, and thorough washing, have to be dried, a large open space provided with wooden platforms arranged in terraces and exposed to the sun being required for this purpose. Adjoining this should be a long shed for storing the dry glue stock.

The transport of the bones is much facilitated, and time and labor are saved by a railroad and the use of small cars, such as are employed in mines for carrying ores and coal.

The room in which the glue stock is boiled should communicate with the store-shed. It contains the boiler which furnishes the steam required for converting the glue stock into jelly, extracting the fat from the bones, and heating the drying-room. It is advisable to have two boilers, so that in case of one requiring repairs, an interruption of the work will not be necessary.

The vats for converting the glue stock into jelly, of which there should be three or four or more according to the extent of the business, are located as near as possible to the steam boiler. The settling vats, the number and size of which depend on the jelly vats, should be placed in the neighborhood of the latter. They communicate by means of pipes with a cool and airy cellar where the cooling boxes are arranged and into which the gelatinous solution is drawn. The first running from the jelly vats is generally sufficiently concentrated, but those obtained later on require concentration. We have already described

an apparatus for this purpose which answers all the requirements of a small factory. For large establishments it is recommended to use a vacuum pan, such as is employed in sugar-houses, as the best means of concentrating large quantities of gelatinous solution without the use of too high a temperature.

If the jelly is to be bleached with sulphurous acid, the apparatus for developing it must also be placed in the neighborhood of the jelly vats, and the entire arrangement be such that the escaping gases make their exit through a chimney.

Should a purification by filtering be required before running the gelatinous solution into the settling vats, the apparatus required for this purpose should also be placed in the immediate neighborhood of the jelly vats.

After solidification of the jelly in the cooling boxes, the latter are hoisted to a room located above the boiler-house or over the room containing the crushing mill, hollander, etc., where it is cut into cakes.

The arrangement of this room is very simple. All the utensils required are a large table with a stone top, upon which the cooling boxes are inverted, tools for detaching the glue from the sides of the boxes and cutting it into cakes, and drying nets.

The drying-room, which adjoins the other room, requires, on the other hand, most careful construction. The side walls are wainscoted with wood up to the ceiling. It is best to leave a space of about 0.10 meter (0.32 foot) between the walls and the wainscot, and fill it in with sawdust or other poor conductors of

heat. The windows, of which there should be no more than required for the admittance of sufficient light, should be double in order to separate the interior air from the exterior.

The air required for drying the glue is strongly heated by passing from outside the factory through two pipes running through the fireplace of the steam boiler, and, on entering the drying-room, causes an upward current, which removes the aqueous vapors through several apertures in the ceiling. Along the floor, between the frames upon which the nets are placed, run wide pipes, through which passes the steam escaping from the jelly vats and, if necessary, an additional supply taken from the steam boiler. The water formed by condensation runs back into the vats.

Besides the drying-room, it is advisable to have a drying-shed, so as to be able to take advantage of the favorable seasons for drying a portion of the glue in the air. It may form the second story of the store-shed for crude glue, and should be built so as to keep off rain and sun without obstructing the free passage of air.

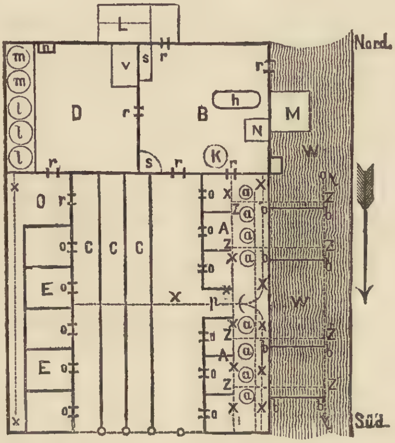
There is nothing in the arrangement of the store-room for the finished product which requires special mention.

The accompanying illustration (Fig. 8) is not intended for a building plan, but only for a sketch to illustrate the arrangement of the rooms, machines, and apparatuses.

A, is the shed for the reception of the glue stock as

brought to the factory. If already sorted it is thrown through the aperture *o* into the respective bin, otherwise into the roofed space *p*, where it is sorted and then distributed into the different bins. From the

Fig. 8.



bins 1, 2, 3, etc., the material is conveyed to the mill *K*, and after crushing, to the boiler, or extracting apparatus *s*. *h*, is the hollander used for mixing and washing; and *a*, are the lime and acid vats, or, in place of the latter, the boxes for the exhaustion of air. The lines *z z*, indicate the uprights to which the baskets or boxes containing the limed material are suspended and carried over the water, where they are submerged, by means of a tackle handled by a workman standing upon the small bridge *b b*.

C, are the drying platforms arranged in terraces along the shed *E*, which contains the crude glue. *o*, are the apertures for throwing in the dried materials. *O*, is a vestibule, *D*, the boiling-room, *l*, the jelly vats, *m*, the settling vats, *n*, the apparatus for developing sulphurous acid, *v*, the vacuum pan for concentrating the gelatinous solutions, and *L*, the boiler-house with two boilers.

The drying-room is above the room *D*, and the room for cutting the glue cakes, and the store-room for the finished product over the room *B*. *M*, is the water motor, either a turbine or water-wheel, *N*, the transmission of power, and *W*, the stream of running water.

3.—Machines and Apparatuses Used in a Glue Factory.

The arrangements for preparing raw materials are the same for large and small factories, the only difference being in the number of vats and in the size of the store sheds.

Various devices are in use for comminuting bones. In small establishments they are broken into a suitable size by means of a wooden mallet faced with iron, while in large factories different kinds of machines, such as stampers, crushers, mills, etc., are used. We will here describe the mill previously recommended. Two heavy millstones, each 1 to 1.5 meter (3.28 to 4.92 feet) in diameter and 0.3 to 0.4 meter (0.98 to

1.31 feet), high run in a circular granite trough, and crush the bones shovelled into the trough. The motive power is either steam or water. Only one workman is required for attending the mill. On leaving the mill the crushed bones pass into an inclined cylinder sieve made of strong parallel iron rods. The fine particles fall into a box under the sieve and the coarse parts into one under the end of the sieve.

In Fig. 8 the mill is indicated by *K*. The bones are brought to it from the store sheds upon the railroad *X*.

In the United States a powerful crusher of special construction and capable of crushing twenty tons of bones to the size of a joint of the thumb, in twelve hours, is used.

After comminuting and sorting, the bones are placed in an apparatus for extracting the fat. Any ordinary boiler of sufficient capacity, which is filled with water and heated by steam, can be used for the purpose. It is provided with a faucet for drawing off the water which is allowed to run into cooling vats by means of a system of pipes. The discharge aperture of the boiler must be provided with a wire sieve to prevent the escape of particles of bone with the water. In the cooling vats, which may stand in the open air, the fat collects upon the surface of the water, and is lifted off in the form of a cake. The remaining water can be used as a fodder for hogs. Some flour, bran, roots, etc., are placed in the feeding trough, and the warm water in the vats conducted to them by means of pipes. In

Fig. 8, this arrangement is indicated in the upper right corner.

This arrangement is of course omitted in establishments where the fat is extracted by means of bisulphide of carbon. Although available by-products are lost by this process, the yield of fat is much larger and the product cleaner. The same kind of apparatus is used as in oil mills.

The use of benzine for freeing the bones from fat has been lately introduced in the United States, and promises to completely revolutionize all previous methods. The American patents, of which we give a description, are, we believe, owned by the firm of *Baeder, Adamson & Co.*, of *Philadelphia.*

A mode of extracting oily, fatty, and resinous matter from animal and vegetable substances by causing liquid hydrocarbon to trickle through a mass of such substances in a closed vessel, and preventing it from being subjected to steeping or flooding, is shown in Figs. 9 and 10. It is the invention of Messrs. Wm. Adamson and Charles F. A. Simonis, of Philadelphia, Pa., and relates to the treatment of animal and vegetable substances with hydrocarbons, for the purpose of extracting therefrom oily, fatty, and resinous matter; and the object of this invention is to cause hydrocarbon to trickle through such substances instead of flooding the same, so that it will take up the oily, fatty, and resinous matter without any of the albuminous or gelatinous ingredients.

Fig. 9 is a vertical section of apparatus wherewith this invention may be carried into effect; Fig. 10, an inverted plan view of part of Fig. 9.

Fig. 9.

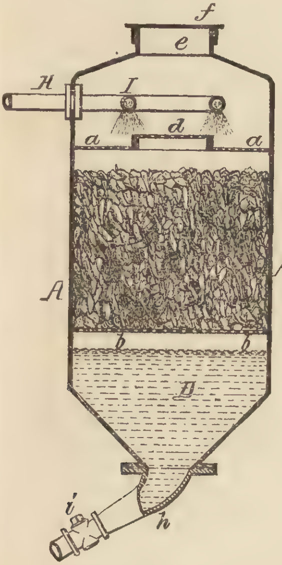
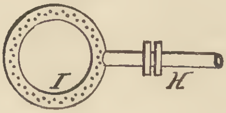


Fig. 10.



A is a vessel, preferably of cylindrical form, and containing an upper perforated diaphragm, *a*, and lower perforated diaphragm, *b*, the former having a central opening, through which the material to be treated may be introduced between the two diaphragms, and this opening having a detachable perforated cover, *d*.

On the top of the vessel there is an opening, *e*, furnished with a detachable cover, *f*, and at the bottom of the vessel there is an outlet-pipe, *h*, furnished with a suitable cock or valve, *i*.

Liquid hydrocarbon, preferably such as is of a volatile character—benzine, benzole, or gasoline, for instance—is introduced into the vessel above the diaphragm *a* through a pipe, *H*, and perforated ring, *I*, or otherwise, the hydrocarbon passing through the diaphragm and falling in a shower on to the substance contained in the vessel.

The hydrocarbon will trickle through the mass, taking up whatever oily, resinous, or fatty matter it comes in contact with until it falls through the lower diaphragm into the space *D*, whence it may be drawn off from time to time through the outlet-pipe, *h*.

In extracting oily, fatty, or resinous matter from vegetable or animal substances by hydrocarbons, it has been the practice either to subject them to hydrocarbon vapors, or to immerse or steep the substances in hydrocarbon until the latter takes up the oily, fatty, or resinous matter.

The vapor plan is preferable in treating wet animal substances, such as offal; but for dry vegetable or animal matter—seeds, for instance, or the residuum resulting from the rendering of tallow—we prefer the plan before described.

The flooding or steeping of animal or vegetable matter in liquid hydrocarbon results in a mixture or emulsion of gelatinous, albuminous, and fatty or oily matter,

combined with animal or vegetable tissues, the whole forming an amalgamated mass; hence, whatever fatty or oily matter is extracted is accompanied with more or less of the suspended gelatine or albumen, either of which is difficult to remove from the oil or fat, and has a tendency to discolor the same.

This difficulty, it has been found, can be obviated by preventing the hydrocarbon from remaining in a quiescent state in contact with the material; in other words, by causing it to trickle through the mass, which, by this plan, retains its granular condition, and gives out its oil or fat to the hydrocarbon without the albuminous or gelatinous matter.

In the apparatus before described, for instance, an occurrence of the objectionable flooding of the material, tending to bring about the results previously mentioned, is obviated by never permitting the extract in the lower portion of the vessel *A* to reach the lower diaphragm *b*. By drawing off the extract from time to time, any impediment to the free discharge of the hydrocarbon with such oily and resinous matter as it has taken up, through the lower diaphragm, is prevented, and a continuous dripping of the hydrocarbon through the mass secured.

The extract obtained by the trickling or filtering process is much more concentrated than that obtained by the steeping and flooding process.

Adamson's Method for Treating Substances with Hydrocarbon Vapor, for the Purpose of Extracting Oils, Fats, etc.

This improvement is intended to prevent the fetid or other odors imparted to the vapor from the substances treated from being recommunicated to the said substances, and to the extracts obtained therefrom through the medium of the vapor from the re-used hydrocarbon. The vapor is obtained from benzine, benzole, etc.

Fig. 11 represents, partly in section, the apparatus whereby the invention may be carried into effect.

A is a vessel in which the substances have to be treated by hydrocarbon vapor, the said substances being introduced into the vessel through a man-hole, *x*, and deposited on a perforated diaphragm, *B*, the man-hole being provided with a suitable cover. A steam-coil, *D*, is placed in the vessel in a space beneath the diaphragm, and liquid hydrocarbon is introduced into the said space, and is there vaporized by the steam-coil. The vapor rising through the perforated diaphragm permeates the substance upon the same, so as to extract therefrom the oily, fatty, or resinous matter, which passes downward through the diaphragm into the space below the same, whence it may be drawn off from time to time through the discharge-pipe *j*. Liquid hydrocarbon may be introduced from a tank, or from a source explained hereafter, into the top of the vessel *A*, so that it will pass through the material and be vapor-

ized when it reaches the coil; the said material being in this case subjected to a downward current of liquid hydrocarbon and an upward current of vapor.

Previous to this invention it was Mr. Adamson's practice to cause the vapor, after acting upon the substances in the vessel, to pass through a worm in a condenser, the lower end of the worm communicating with the vessel, *A*, beneath the diaphragm, as shown in Fig. 13, p. 105, so that the hydrocarbon was used over and over again. But in practice this has been found objectionable in many cases for the following reason:—

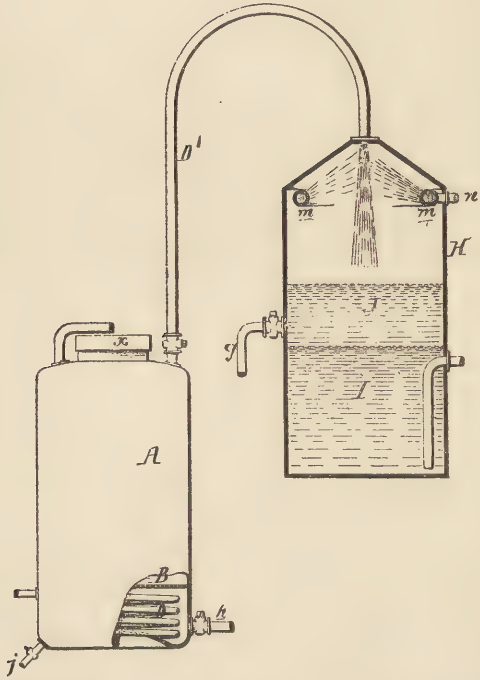
In treating animal offal, for instance, for the extraction of fats, fetid odors are imparted to the hydrocarbon vapor, and remain, to a considerable extent, in the condensed vapor when the latter is restored to the vessel *A*; hence the fetid odors were recommunicated both to the fatty extracts and to the material. The same objections have been experienced in treating meat for preservation and vegetable matter for the extraction of oil by hydrocarbon vapor.

This difficulty is obviated in the following manner: The vapor-pipe *D′* communicates with a vessel *H* at the top of the same, and the vapor is met by numerous small jets of cold water—in the present instance, from a perforated tubular ring, *m*, into which the water is forced through a pipe *n*.

Many different appliances may be used, such as roses, revolving jets, etc., for causing a spray through which the vapor must pass, and by which it must be

condensed. The result of this will be a supply, *I*, of tainted water on the bottom of the vessel, *H*, and a quantity, *J*, of washed and purified hydrocarbon above the water, the latter having taken up the fetid odors.

Fig. 11.



The washed hydrocarbon may be drawn off through a pipe, *g*, into any suitable vessel, and thence intro-

duced through the pipe h into the vessel A, or may pass directly into the latter to be again vaporized therein, the vapor after permeating the material and passing through the pipe D' being simultaneously condensed and washed in the vessel H, preparatory to being returned in the condition of purified liquid hydrocarbon to the vessel A.

By the practice of this process, the inventor is enabled to obtain a purer extract than heretofore, and, at the same time, the substances acted upon are more free from noxious odors.

Changes may be made in the apparatus shown in Fig. 11, as, for instance, the vessel A may consist of a horizontal hollow cylinder, and the vaporizing of the hydrocarbon may be accomplished otherwise than by a steam-coil.

Adamson's Method for Treating Substances with Liquid Hydrocarbon for the Purpose of Extracting Oils, Fats, etc.

This invention, which is that of Mr. Wm. Adamson, relates to a method of treating animal and vegetable substances with liquid hydrocarbons, such as benzine, benzole, etc., for the purpose of extracting from such substances oils, fats, etc.

The object of this improvement is to prevent the fetid and other odors imparted to the liquid hydrocarbon by the substances treated from being recom-

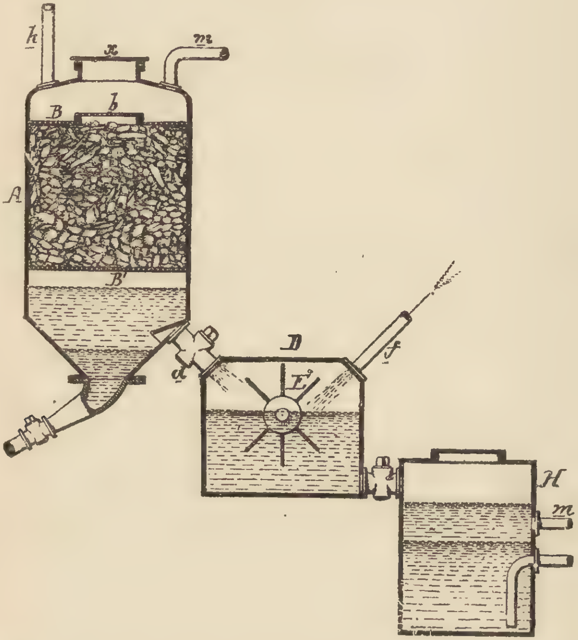
municated to substances and to the extracts therefrom by the liquid hydrocarbon when re-used.

In Fig. 12, there is shown a sectional view of apparatus whereby this invention may be carried into effect.

A is a vessel into which the substances to be treated are introduced through a man-hole, *x*, provided with a suitable detachable cover, and through an opening in the upper perforated diaphragm, *B*, a detachable perforated plate, *b*, being placed over the opening after the substances have been passed through the same, the substances being supported by the lower perforated diaphragm, *B′*, beneath which is a space for receiving the extract and liquid hydrocarbon after the latter has percolated through the mass in the vessel. The extract, which occupies the lowest position in the vessel, may be removed therefrom from time to time prior to being purified by distillation or otherwise. The liquid hydrocarbon is permitted to pass from time to time through a pipe, *d*, into a vessel, *D*, where it is met by jets of water from a pipe, *f*, the hydrocarbon and water being thoroughly agitated in the vessel by a revolving paddle-wheel, *E*. This washing of the liquid hydrocarbon may be accomplished by different appliances. For instance, the paddle-wheel may be dispensed with, and water forced upward into the vessel from below in the form of numerous small jets. The water and hydrocarbon after this washing operation are permitted to pass into the subsiding-vessel, *H*, the hydrocarbon being above and the water below, the fetid and other odors divided by

the hydrocarbon from the substances in the vessel, *A*, having, during the washing operation, been transferred to the water, which may be drawn off from time to time.

Fig. 12.



The washed and purified hydrocarbon may be pumped directly through a pipe, *m*, into the vessel, *A*, to be re-used for treating the substances therein; or it may be pumped, first, into a reservoir, and permitted to flow from the same into the said vessel, *A*.

More or less hydrocarbon is wasted by being drawn off with the extract, and to make up for this loss a supply may be introduced at intervals from a tank through the pipe, *h*.

By the practice of the process described above, the inventor is enabled to obtain a purer extract than by the ordinary process of treating substances with liquid hydrocarbon. At the same time the substances treated will be much more free from noxious odors than when the hydrocarbon is used over and over again without washing.

It is not essential strictly to adhere to the apparatus shown in Fig. 12, as the construction of the apparatus will, in fact, depend in a great measure on the locality in which it is to be situated.

Adamson's Process for Removing Hydrocarbons from Substances which have been treated therewith.

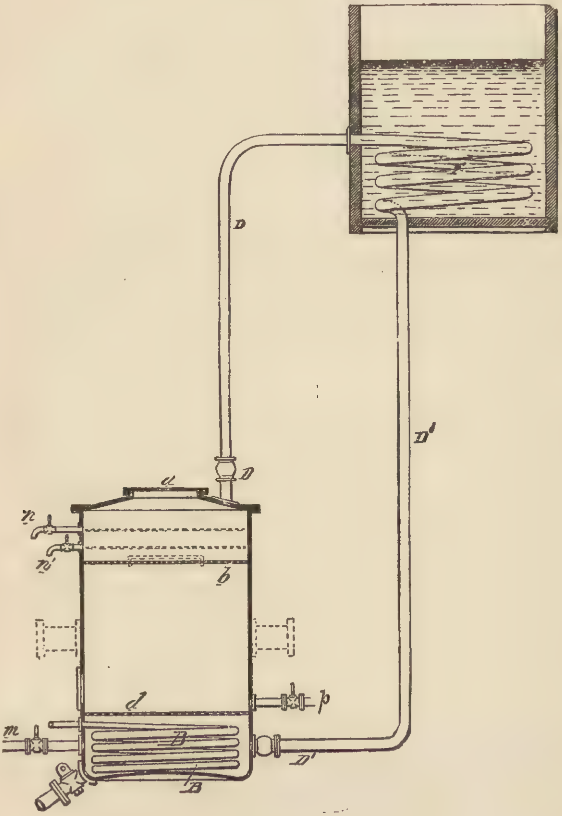
This process, which is the invention of Mr. William Adamson, consists of washing from animal and vegetable substances the hydrocarbon which they retain after being treated therewith for the extraction of oils, fats, etc., and for other purposes.

Different apparatus may be employed for carrying out this process, and it may be conducted in the same vessel in which the material is treated with hydrocarbon.

The vessel, which is shown in Fig. 13, has been found to answer well for this purpose.

This vessel is furnished with a suitable detachable cover, *a*, and with two perforated or wire-gauze diaphragms, *b* and *d*, both extending across the interior

Fig. 13.



of the vessel, one near the top and the other near the bottom of the same.

A steam-coil, *B*, communicating with any adjacent steam-generator, is contained in the vessel below the lower diaphragm, to vaporize the hydrocarbon, the vapor passing through the substance between the two diaphragms and out through a pipe, *D*, which passes through a condenser, *E*, the latter restoring the hydrocarbon to a liquid form, in which it is reconveyed to the vessel through a pipe, *D'*.

In practising the washing process a pipe, *m*, to introduce water into the vessel, and one or more outlet-pipes, *n n'*, two in the present instance, are necessary. There may also be a pipe, *p*, through which air can be introduced into the vessel, under the circumstances explained hereafter.

When the treatment of the material in the vessel with hydrocarbon vapor or liquid hydrocarbon has been completed, steam is cut off from the coil *B*, the pipes *D* and *D'* are closed, and the cover *a* may be removed.

Water is now admitted through the pipe *m* to the space in the vessel below the diaphragm *d*, and the cocks of the outlet-pipes *n n'* are opened.

The water permeates the material, passes upward through the same, and carries with it the hydrocarbon, the latter having a tendency to rise with the water.

As the water, and whatever hydrocarbon accompanies it, pass through the upper diaphragm, *b*, the hydrocarbon will at once rise to the surface, and will

pass through the upper outlet-pipe, *n*, into any suitable receptacle, the water passing off through the lower outlet-pipe.

If this mode of separating the hydrocarbon from the water is practised, the admission of water to the vessel should be such in respect to the outflow that the liquid will remain at or near a uniform level, that is, the surface of the liquid should bear the relation shown in the drawing to the upper outlet.

The water and hydrocarbon, however, may be drawn off indiscriminately into a suitable receptacle, and then separated by decantation; but it is advisable in all cases that the water should extend above the mass of material in the vessel, so that the hydrocarbon can at once rise to the surface as it escapes from the substance.

When the material is of such a character as to be closely packed and not easily displaced by the upwardly-flowing water (and this is especially the case with seeds which have been treated with hydrocarbons), it is necessary to agitate the mass, so that the water can gain access to every part thereof. This agitation the inventor prefers to effect by air under pressure introduced through a pipe, *p*, although mechanical appliances may be used for the purpose.

It will be understood that the process may be conducted in a vessel separate from which the substances have been treated with hydrocarbon. A vessel similar to that shown, for instance, but without the coil and pipes, *D D′*, may be used, and may be furnished with

trunnions (shown by dotted lines) and adapted to bearings, so as to be easily tilted when its contents have to be removed; or the vessel may have an opening near the lower diaphragm for the withdrawal of its contents, a suitable detachable door being adapted to the opening.

The following is the benzine process as patented by *F. Seltsam* (German patent).

The process is based upon the action of benzine vapors, which, by penetrating the bones, whether whole or comminuted, dissolve and remove the fat. The apparatus required consists of an extracting vessel provided with a man-hole, arrangements for direct and indirect heating by steam, a manometer, false bottom, etc., further a still with a steam worm and blast pipe, a cooling apparatus with an arrangement for separating water and benzine, a reservoir for the benzine, an air-pump, and the necessary connecting pipes with the required cocks. The separate parts of the apparatus communicate with each other in such a manner that the volatile solvent always circulates in closed pipes or apparatuses, and, to prevent evaporation, comes as little as possible in contact with the air. To reduce danger from fire to a minimum, it is advisable in case work is carried on at night, to illuminate the room from the outside. After many costly experiments iron proved the best material for the apparatus. It should be galvanized wherever it comes in contact with the fat. The execution of the process is very simple. After charging the extracting vessel with

bones the required quantity of benzine (about 16 per cent. of the weight of the bones) is forced from the reservoir into the extracting vessel by means of the air-pump, and heated with indirect steam. The vapors which are developed force the air from the bones and the extracting vessel. A portion of the vapor reaches the cooling apparatus, and after condensing is reconducted to the reservoir. After exhaustion of the air, the heating is continued, the extracting vessel being entirely closed in order to obtain a pressure of several atmospheres, which is kept up until the bones are completely freed from fat. The fatty solution, which collects in the space between the true and false bottom, is then forced into the still, which stands at a lower level than the extracting vessel, and the benzine is distilled off. By directing a small jet of steam upon the mass, the troublesome formation of scum is rendered innoxious, and a complete separation of fat and benzine is effected. The benzine vapors condense in the cooling apparatus, while the water, which may have passed over, is separated from the benzine in a special vessel, and the benzine reconducted to the reservoir. By subjecting the bones to the direct action of steam they are freed from the last traces of benzine, the vapors of which pass through the same course as described above. The fat remaining in the still is then removed, and can be brought into commerce without further manipulation.

A special arrangement is required for leather and leather waste. Even if limed material is bought, it is

best again to immerse it in lime-water, after which it should be thoroughly washed in willow baskets in the same manner as bones, or in a hollander. The position of the hollander is indicated by *h* in Fig. 8. It consists of an oblong wooden or iron tank about 3 meters (9.84 feet) long and 1 meter (3.28 feet) wide. A cylinder about 0.75 meter (2.46 feet) in diameter, and provided with about fifteen or twenty steel blades, is placed across the tank. The apparatus is divided into two parts, the working side, in which the material is torn or shredded between the knife-blades on the cylinder, and the running side, into which the shredded material is thrown by the revolving cylinder. Under the cylinder is a massive oak block, called the craw, its concave surface comprising the fourth part of the cylinder. One side is a little and the other much inclined.

After liming, the glue pieces are cleansed in the hollander by the admittance of a constant current of fresh water during the shredding process.

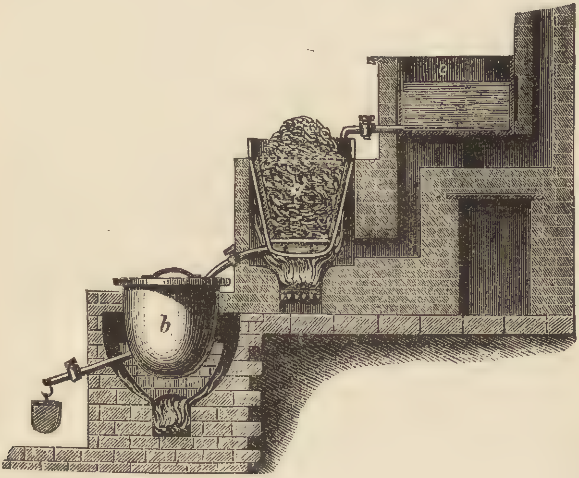
The apparatus also does excellent service where tanned leather is worked, as it is especially well adapted for tearing the material into fine shreds and washing out the tannin, which is of the utmost importance.

When the waste is sufficiently comminuted and thoroughly washed, the water is drawn off and the material, after pressing out, brought into the glue-boiler.

Fig. 14 represents a convenient apparatus for boil-

ing waste into glue, which is especially adapted for small establishments. It consists of three caldrons upon as many different levels. The lower caldron, *b*, serves for the settling and clarification of the glue. It

Fig. 14.



communicates with the second caldron, *a*, which contains the material to be acted on, by means of a pipe provided with a stopcock, and is sufficiently heated by a small fire to keep the glue liquid without allowing it to reach ebullition. The upper caldron, *c*, which is heated by the waste heat of the chimney, serves as an economical reservoir for hot water. The end of the discharge-pipe of the settling caldron is provided with

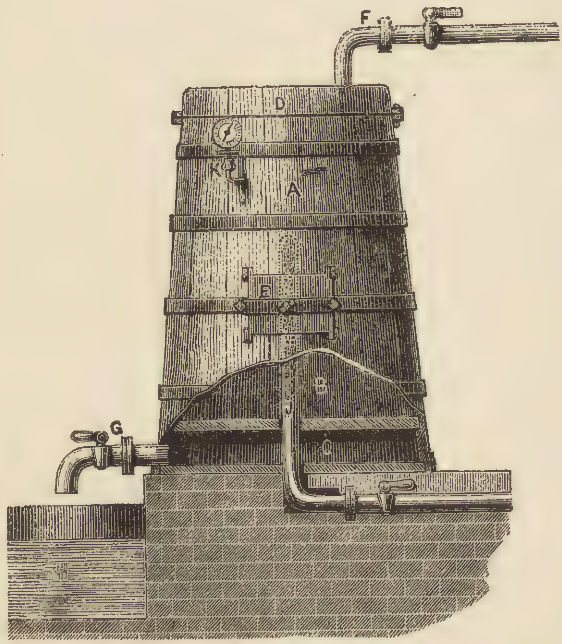
a filter of woven wire. As the sides and bottom of the second caldron are lined with straw, which acts as a preliminary filter, the glue runs off quite clear from the settling caldron.

When this mode of manufacture is adopted, two boilings can be made per day, under favorable circumstances, so that, if the caldron has a capacity of 100 kilogr. (220 lbs.) of raw material, which will yield from 50 to 60 kilogr. (110 to 132 lbs.) of dry glue, the daily fabrication will be about 100 kilogr. (220 lbs.) of finished product.

The plan of manufacture pursued in all extensive glue factories differs somewhat from the above method. Instead of the direct application of fire to metallic caldrons, the materials are dissolved in vats by the introduction of steam. A further advantage is that a vat will hold three to four times the quantity of raw material, which facilitates the work and secures a better yield, while the consumption of fuel is scarcely larger. Fig. 15 represents such a vat. It is 2 to 3 meters (6.56 to 9.84 feet) high and 1.5 meter (4.92 feet) in diameter. It is provided with a lid *D*, which is removed for charging the vat. The aperture *P* in front serves for the removal of the residue. Above the true bottom there is another false bottom perforated and movable which can be covered with straw for preliminary filtration. The steam reaches the glue stock through a pipe which passes through the actual and false bottom and is perforated above the latter. The resulting jelly collects between the true and false

bottom where it is less exposed to the action of hot steam. The escaping steam passes through the pipe *F*, which is provided with a stopcock. The pressure in the boiler is indicated by the manometer *K*. After

Fig. 15.



throwing the materials into the vat, they can be covered with warm water, or, after the lid is closed, warm water is introduced from a reservoir through a special pipe and distributed over the material through a rose.

The vat stands upon a frame sufficiently high to allow of conveniently placing a vessel under the pipe *G*, through which the jelly is discharged. The vessel, when full, is conveyed to the settling vat, or the arrangement may be such that the jelly is directly run into the settling vat.

As the jelly requires at least twenty-four hours for clarification, and the vat is filled and emptied twice during that time, the clarifying vat should be of sufficient capacity to hold twice the quantity of jelly obtained from one boiling. But it is better to have two settling vats for each boiling vat, in order to keep the first jelly, which is always cleaner and more concentrated, separate from the last run. To be able to draw the upper layers of purer jelly into cooling boxes by themselves, the settling vats are provided with faucets at different heights.

To keep the jelly liquid during clarification, it is recommended to surround the settling vats with a wooden or sheet-iron jacket, and fill the intermediate space with a material non-conductive of heat, or heat it by the introduction of steam. To prevent putrefaction of the jelly during settling at a high temperature, the vats should be kept scrupulously clean, and rinsed from time to time with pure hot water. It is also advisable to line the vats inside with sheet iron.

Where the jelly is to be chemically cleansed and discolored by means of sulphurous acid, the apparatus for developing the latter should be placed in the immediate neighborhood of the settling vats. The vapors

of sulphurous acid pass into the settling vat through a pipe reaching to the bottom, and bleach the gelatinous solution by ascending through it. For the escape of the vapors the air-tight lid of the vat is provided with a pipe communicating with a chimney.

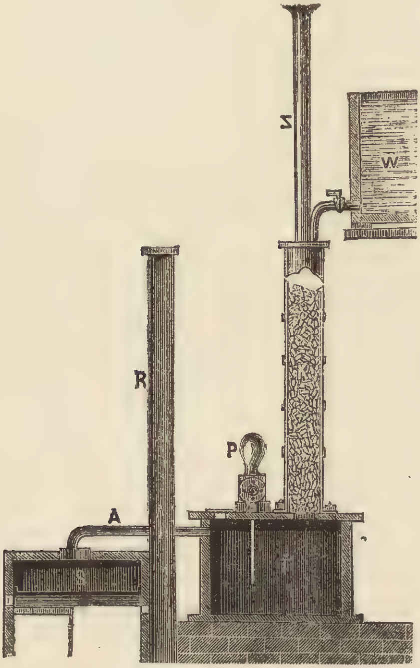
In the United States, where hydrochloric acid is expensive, sulphurous acid is used not only for bleaching purposes, but also for the disintegration of bones. The washed bones are thrown into a suitable wooden vat and treated with a saturated solution of sulphurous acid. The duration of the action of the acid varies very much according to the condition of the material, and can only be determined by experience. The material thus treated yields a soup almost as clear as water, which, after evaporation in the vacuum pan, is equal, as regards clearness and lustre, to the best glue prepared from scraps of hide. The fat extracted from the bleached bones is lighter in color and has not the disagreeable odor of ordinary bone fat, and consequently brings a better price.

For the development of sulphurous acid, Dr. Bruno Terne, of Mass., has constructed a very simple apparatus (Fig. 16). The sulphur is burned in *S*, *A* is the escape pipe of stone, *T* the collecting reservoir, *D* the coke column, *Z* the draught regulator, *W* the water reservoir, *P* the steam-pump for acid, *R* chimney for the sulphur burner.

Filtration through animal charcoal in a filtering vessel surrounded by a jacket and heated by steam has

also been found to answer the purpose, and is used in many of the large American glue factories.

Fig. 16.



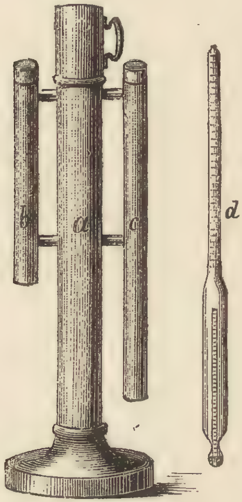
A high pressure is used for filtration, and the jelly solutions are much diluted in order to facilitate their passage through the filter. Where animal charcoal is used for filtering, an apparatus is required to reduce the clarified solution to the degree of concentration

necessary for its solidification to prevent it from running through the meshes of the net. We have already described an apparatus suitable for small factories. But in the large American factories, where great quantities of solutions have to be quickly handled, a vacuum pan is used. It does not vary materially from that employed in sugar-houses. The essential parts of every kind of vacuum pan are: 1, a boiling-pan, and 2, an apparatus for removing the air and the developed vapors. The boiling-pan consists of two segments of a sphere screwed together air-tight and provided on the top with a helmet, which communicates with the condenser by means of a pipe. In the lower part of the pan is a spiral pipe, through which the steam enters and heats the jelly, and as the latter begins to boil at 46.1° C. (115° F.), there is no danger of its losing its quality by evaporation. By opening a lever valve the concentrated jelly is discharged through a pipe into the cooling-boxes. For refilling the pan it is connected with the air-pump by means of a pipe. After sufficient rarefaction of the air, which is indicated by a manometer, the jelly, on opening the pipe connecting the jelly reservoir with the pan, is forced into the latter by the pressure of the outer air. By passing steam through a pipe into the pan and the condenser, the work of the air-pump is assisted. A double-barreled air-pump carefully constructed is the best for the purpose. In the selection of such an expensive piece of machinery as a vacuum pan, the glue boiler should consult a specialist, as otherwise he may

have to pay very heavily for an article of no value to him.

To obtain in all cases a product of equal concentration, it is advisable to have an instrument which will indicate the amount of dry glue in the solution. (Fig. 17.)

Fig. 17



By immersing a glass aerometer in the glue solution, the percentage of glue is indicated by a scale registering from 0 to 70 per cent. with the jelly or glue solution at a temperature of 75° C. (167° F.)

To measure the temperature quickly, a thermometer is added, and for the execution of the entire test, a

sheet-iron vessel consisting of a large and two small tubes, *a*, which, when not in use, serve for the reception of the glass instruments contained in a special case. For testing, the small cylinder is placed in the large tube, *a*, and filled with jelly with the cap, which serves as a cover, while the large tube is filled with hot water to raise the temperature of the jelly to the required degree. By immersing the two instruments, aerometer and thermometer, in the tubes filled with the fluid to be tested, the temperature and percentage are readily read off.

After clarification and concentration the gelatinous solution is discharged into the cooling-boxes, which, as previously stated, should be arranged in a cool and airy room.

Instead of using wooden or sheet-iron cooling-boxes, it is recommended to pour a layer of gelatinous solution of the desired thickness of the glue cakes upon large polished stone slabs, and when congealed, cut it into cakes, which are placed upon the nets to dry. The advantages of this method are obvious. The solution cools more quickly by being exposed in a thin layer upon a large surface, which reduces the danger of spoiling, and a strong evaporation of water and consequent concentration take place. Besides, the cakes show the smooth surface of the polished stone, and become in a short time so hard, that when placed upon the nets, the twine will make no impression upon them.

Where cooling-boxes are used, the jelly, when con-

gealed, is cut into cakes after having been placed upon a table with a stone plate, by inverting the boxes. Figs. 18 and 19 represent the tools used for cutting the jelly into cakes, which have already been described.

Fig. 18.

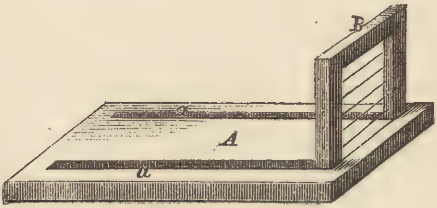
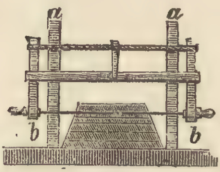


Fig. 19.

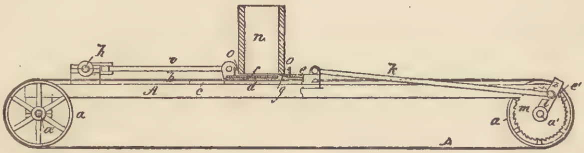


The machine shown in Figs. 20 and 21 is the invention of Mr. J. Schneible, and it is for slicing and spreading glue-jelly preparatory to drying; and it consists in the combination of a reciprocating cutter with the jelly-box and a travelling belt-carrying frame for receiving the slices as cut by the knife.

Fig. 20 is a partly-sectional side view of the machine, and Fig. 21 is a cross-section of the same.

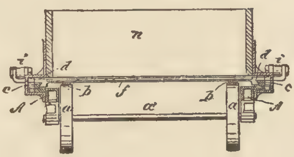
A A, are side-bars of the supporting-frame, fitted at the ends with cross-shafts, a', carrying pulleys, *a a*, around which are endless belts, *b b*. *c c*, are slide-ways upon the bars, *A*; and *d d*, are slides carrying

Fig. 20.



a cross-plate, *e*, and also a plate, *f*, to which plate *e* is attached a knife or cutter, *g*, the cutting edge of which is at the edge of the plate, *f*, and about the same thickness as the slices to be cut. The cross-

Fig. 21.



shaft, *h*, is fitted in boxes on bars, *A*, and near one end thereof, it is provided with cranks at its ends, which connect by rods, *i*, to the slides, *d*.

From the opposite ends of the slides, rods *k* pass to loose arms, *l*, on the shaft at the opposite end of the machine, and the arms, *l*, carry pawls, l', that engage

ratchet-wheels, *m*, fixed on the shaft, so that the shaft, *h*, being revolved, the slides, with plates, *e f*, are reciprocated, and at the backward movement of the cutter the pawls engage the ratchet-wheels, and belts, *b*, are moved a distance equal to the movement of the knife.

The jelly-box, *n*, is fixed to side bars, *A*, by brackets at its ends, as shown in Fig. 21, and is placed above the cutter and the plate, *e*, so that when the plate, *f*, is drawn out from beneath the box, the plate, *e*, takes its place for holding up the block of jelly.

In operation the block of jelly is placed in box *n*, resting on plate *e*. A frame provided with netting—such as is used for drying glue—is placed on belts, *b*, beneath the box, and the shaft, *h*, being rotated by power, the cutter moves forward and cuts a slice from the jelly. The plate, *f*, at the same time moving away, the slice passes upon the frame, and the return movement taking place, plate *f* is carried beneath the jelly-block, and the belts being at the same time moved, the frame is carried forward in position for receiving the next slice apart from the first one. In this manner, as slice after slice is cut, they are spread on the frame, and the frames, when filled, are carried to the end of the machine for removal. The plate, *f*, is adjustable, so as to vary the thickness of the slices cut.

The box may be divided into cells of any size desired, so that each movement of the knife will cut a slice from the bottom of each cell, and the box extend-

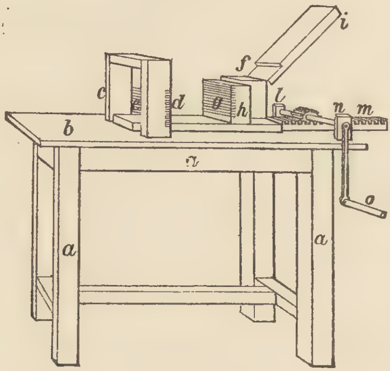
ing the full width of the drying-frames, all the slices cut at once will be properly spread.

In order to keep the plates, *e f*, moist, so as to prevent the glue-jelly from sticking thereto, there are fitted at the sides of jelly-box, *n*, open-bottomed boxes, *o*, containing fibrous material soaked with water, which, resting on plates, *e f*, keeps their surfaces moist.

This machine saves the troublesome and expensive work of spreading the jelly by hand, as has been heretofore practised.

The knife is to be attached to plate, *e*, in any suitable manner, and the surface of plate, *f*, may be corrugated, so as to slide on the jelly more readily.

Fig. 22.



The cutting apparatus patented by M. Devoulx, of Marseilles, is much used in France. The machine

stands upon a board or table, upon which are fastened two uprights, far enough apart to allow of the passage of a truck carrying the glue, which is cut into cakes by blades or wires stretched between the uprights.

Fig. 22 shows the perspective elevation of the machine with its truck. The upper part is lifted up for the reception of the glue to be cut up into cakes. The sides are omitted in this figure in order to admit of a better explanation of the separate parts.

Fig. 23 gives the same view, except that the truck, the upper part of which is closed, is between the uprights, and contains the glue to be cut.

Fig. 23.

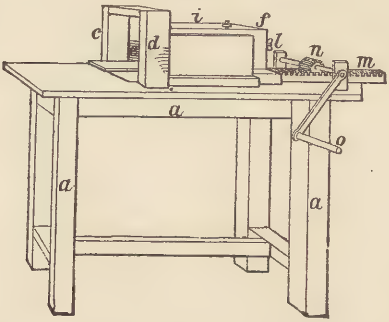
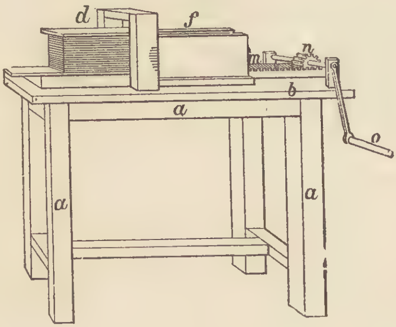


Fig. 24 represents the moment the wires have passed through the glue and cut it into cakes. In all the figures *a* is the wooden frame upon which the machine rests, *b* the table-plate fastened to the frame; *c* and *d*

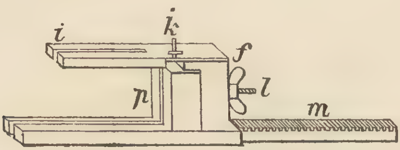
are the uprights, between which the cutting wires are stretched, and *f* the truck carrying the glue.

Fig. 24.



Figs. 25 and 26 show the truck by itself, *g* representing the bottom, and *h* the back, which is provided

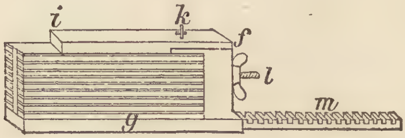
Fig. 25.



with slight grooves into which the wires catch to assure the entire cutting through of the block of jelly; *i* is the upper part of the truck, which opens by means of a hinge, and when closed is fastened with the pin, *k*. This upper part of the truck is fastened to the back part

of the truck by means of a screw, which allows it to be set higher or lower, according to the size of the block

Fig. 26.

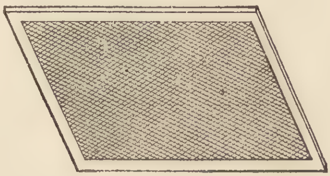


of jelly to be cut; *m* is the bar of a rack fastened to the truck, and serves for moving the latter. The driving gear, *n*, the shaft of which carries a crank, *o*, catches into the rack.

Two boards, one on each side of the truck, serve to keep the block of jelly in position, and guide the truck.

With this machine 120,000 to 130,000 cakes can be cut in five or six hours.

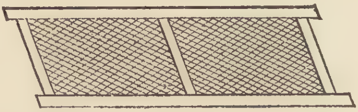
Fig. 27.



The nets upon which the cakes are dried are 2.5 to 3 meters (8.2 to 9.84 feet) long, and consist of strong wooden frames and strong hemp nets; fine tinned iron wire has also been successfully used.

Figs. 27 and 28 represent the form of nets commonly used. As the cakes of jelly have to remain

Fig. 28.



upon the nets two or three days, and frequently longer when the drying process is carried on in the open air, a large number of them is required; large factories frequently having several thousand of them. In order to save nets the cakes of jelly are sometimes hung on horizontally stretched wires, though this can only be done after they have attained some degree of consistency.

Fig. 29.

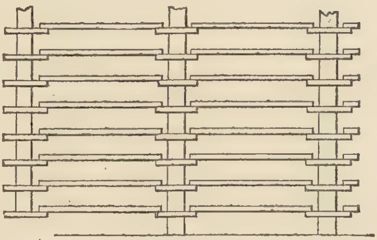


Fig. 29 represents the frames in the drying-room upon which the nets are placed.

V.

GELATINE AND ITS PREPARATION.

Gelatine is a pure bone glue, and its chemical characteristics are, of course, similar to those of glue. It is distinguished by its purity and the thin leaves in which it is brought into commerce. It has in a short time become of great importance, having almost superseded isinglass for clarifying liquors, etc., and its application to various purposes is constantly increasing. Bones are used for its manufacture because they contain 30 to 36 per cent. of glue-yielding cartilage in its purest form.

As gelatine is much used for culinary and medicinal purposes, and for fining beer, wine, and other liquids, care must be had to manage all the processes of manufacture so as to obtain the product absolutely tasteless and free from odor. The materials should be of the best description, the most suitable bones being calves' feet, refuse of turners and button-makers, the bony cores of the horns of the ox and cow. Such bones do not require comminution, but if large bones of horses, oxen, etc., are to be used, it is recommended to break them as small as possible by means of a wooden mallet, and to avoid the use of iron stampers; as the bones become heated by the heavy blows and friction to

which they are subjected during the process, and acquire an empyreumatic odor, which is retained by the gelatine.

The next step in the process is the solution of the glue cartilage. This was formerly effected by the use of steam and water. The crushed bones were placed in a wire basket or cage and this inserted in a small cast-iron cylinder and steam introduced. These apparatuses are constructed similarly to those described in the manufacture of glue. They are connected with a steam boiler, and are provided with an air-tight lid, and a pipe and a rose connected with a water reservoir for pouring water over the bones in order to promote the solution of the glue cartilage. But this process is very slow, four days being required without completely exhausting the bones.

The resulting gelatinous solution is drawn off every hour, the first run, which contains the dirt and grease, being, of course, kept separate from the rest.

100 kilogr. (220 lbs.) of bones yield about 60 kilogr. (132 lbs.) of solid gelatine. Suppose a concentrated 5 per cent. gelatinous solution is to be obtained, then 100 kilogr. (220 lbs.) of bones would yield 1200 kilogr. (2640 lbs.) of gelatinous solution. A part of the water required for this, according to experiments (about 60 per cent.), is formed by the condensation of steam, while the remainder (40 per cent. or 420 kilogr. (924 lbs.)) has to be gradually added. According to this, if the process requires four days

= 96 hours, then 420 : 96 = 4375 kilogr. (9625 lbs.) of water will be required.

It is obvious that this process consumes much fuel and leaves a residue which, though not completely exhausted, cannot be further utilized for the extraction of jelly. The entire process has, in short, come to us from a time when competition did not impose the strictest economy upon every manufacturer. But, as the process is still in use in many localities, we will, for the sake of completeness, give here a description of the apparatus and improved manner of manufacture recently introduced into the factory of D. J. Briers, which is well known for the beautiful product turned out.

D. J. Briers's Method of Preparing Bone Glue.

Description of Apparatus.

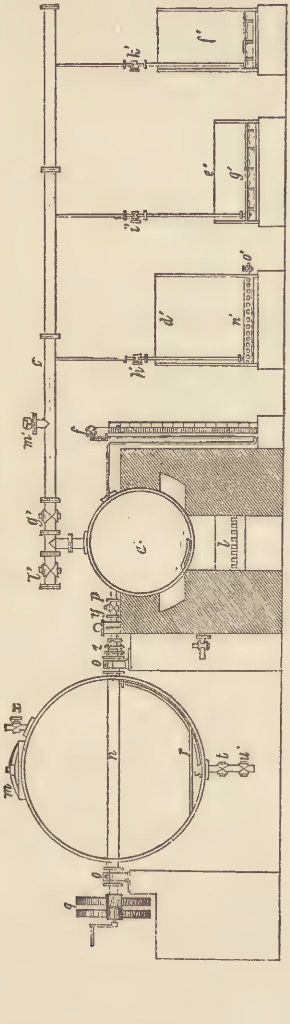
Fig. 30 shows a longitudinal section of the entire apparatus.

Fig. 31 is the horizontal section of the boiler.

a, is the cylindrical boiler 6 meters (19.68 feet) long, and 2 meters (6.56 feet) in diameter. It is made of strong boiler plate doubly riveted, and capable of resisting a pressure of six or seven atmospheres.

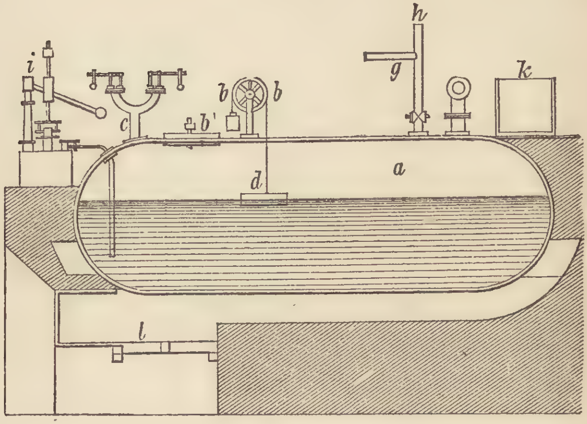
b, is the manhole. It is closed by an oval lid secured by two iron rods and two bolts, so that after placing the lid in position, the boiler is hermetically closed by tightening the nuts upon the bolts.

Fig. 30.



c, is a cast iron fork with two safety valves with levers graduated from 1 to 100 atmospheric degrees.

Fig. 31.



d, is a float upon the surface of the water and provided with a wheel graduated from Nos. 1 to 6. Its object is to indicate during the operation how much water is lost and how much remains in the boiler. Care must be had not to allow the indicator of the wheel to get below No. 1. This figure indicates that the water has reached the highest point in the boiler exposed to the fire, which is consequently the lowest point which the water can be allowed to reach. On the other hand the indicator must not move above No. 6, as the water when standing too high in the boiler and too close to the pipes conducting the steam into the various appa-

ratuses, might mix with the steam and spoil the operation carried on in the drum *e*, Fig. 30.

f, Fig. 30, is a manometer, which indicates the degrees of pressure exerted by the steam in the interior of the boiler. It consists of a wrought-iron pipe bent double, and is filled with mercury 1.22 meter (4.002 feet) high counted from its base. One end of the pipe communicates with the boiler, while the other end is provided with a small brass wheel. Upon the latter is a thread of twisted silk, to the end of which is suspended an iron cylinder of somewhat smaller circumference than the bore of the pipe, so that it can move up and down in it without friction. This cylinder rests always upon the mercury. To the other end of the thread is fastened an indicator of somewhat less weight than the cylinder which, by sliding in a groove in a graduated board placed alongside the pipe, indicates the degrees of steam pressure.

g, is a cast-iron pipe for heating the drying-room, and

h, another cast-iron pipe for heating the store-room for the bones.

i, is a forcing pump for feeding the boiler with water.

k, is a sheet-iron reservoir placed close to the end of the boiler. It is filled with water which is heated by the heat lost in the fireplace in consequence of the draught, and by allowing the smoke to circulate under the reservoir before passing into the chimney. The reservoir communicates with the forcing-pump by

means of a pipe and stopcock, so as to avoid feeding the boiler with cold water.

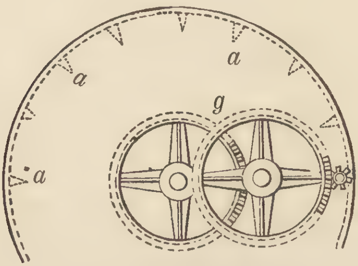
l, is the fireplace, consisting of the grate, door, and cast-iron frame.

The drum *e* is a spherical vessel of strong sheet-iron doubly riveted. It is 3 meters (9.84 feet) in diameter, and capable of resisting a pressure of six to seven atmospheres. It serves for softening the bones with the assistance of steam passed into it from the boiler *a*. It is provided with a manhole similar to that of the boiler.

n, is a wrought-iron shaft passing horizontally through the drum and revolving in the brasses *o*.

g, Fig. 32, is a gearing with a crank, by means of which the drum *e* is revolved. The power of the gearing must be so calculated that one man can turn the wheels when the drum is filled with water.

Fig. 32.



r, is a false bottom perforated in its entire length with holes 12 millimeters (0.47 inch) in diameter,

and is placed about 15 centimeters (5.9 inches) above the true bottom of the drum. It consists of two pieces, and is secured by two nuts, so that it can be easily removed and replaced. Its object is to prevent the bones from clogging up the pipe *s*, and the cocks *t*, *u*.

a, *a*, Fig. 32, are angular iron points inside of the drum *e*. Their object is to facilitate the shifting of the bones when the drum is revolving.

x, Fig. 30, is a cock near the manhole. It is opened about 2 millimeters (0.079 inch) during the operation in the drum. It serves also for the escape of the steam from the drum when the operation is finished.

The cocks *t*, *u*, placed in the lower part of the drum, serve for the escape of steam condensed during the operation.

The steam pipe *p*, Fig. 30, conducts the steam from the vessel *a* into the drum *e*.

y, Fig. 30, is a cock graduated into eight equal parts and placed on the steam pipe *p*, to conduct the steam from the box *z*, into the stuffing box *a′*, and from there into the pipe *s*, then under the false bottom *r*, into the drum *e*.

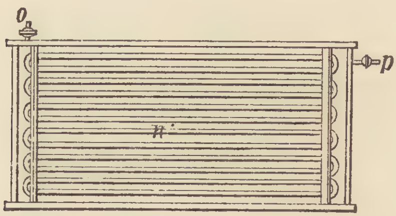
The lid of the cast-iron box *z*, is provided with a safety valve loaded with a weight corresponding to the pressure of one atmosphere.

The wooden vessel or box *d*, the ground-plan of which is shown in Fig. 33, serves for boiling the comminuted bones in order to extract the jelly. This box consists of the following parts:—

n, are cast-iron steam pipes occupying the entire

surface of the box, being placed at equal distances from each other, and connected on their ends by semicircular pieces. The steam, which is allowed to cir-

Fig. 33.



culate in the pipes in order to boil the liquid, enters through one of the ends which rises up vertically and is connected with the cock h', Fig. 30. The other end is secured to the inner side of the box, which is perforated for the admittance of the cock o'. Upon the steam pipes lies a wooden frame-work with linen nailed upon it, the object of which is to prevent the comminuted bone substance from falling under the pipes. The frame must, of course, fit closely into the box.

The cock h' graduated in eight equal parts serves to admit steam into the pipes n', and is opened either entirely or half, or one-quarter, or one-eighth, according to the stronger or gentler ebullition to be produced.

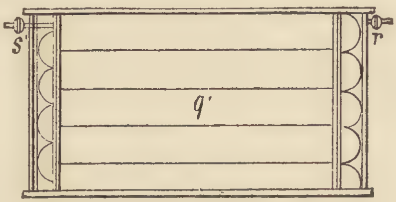
To prevent the steam from becoming stagnant in the steam pipes n', a small jet is allowed constantly to escape through the cock o'. The latter serves also to

run off the condensed steam when it no longer possesses the heat required to keep up ebullition.

p′, Fig. 33, is a cock in the bottom of the box *d′* for drawing off the gelatinous solution from the residue. The box *e′*, Fig. 30, a ground-plan of which is shown in Fig. 34, serves for evaporating the gelatinous solution, which is effected by circulating steam through several tubular pieces of cast iron which form the bottom of the box and are connected in a similar manner as the pipes in the box *d′*.

The cock *i* is graduated and similar to *h′*.

Fig. 34.



The cock *r′*, Fig. 34, is similar to *o′*, Figs. 30 and 33.

s′, Fig. 34, is a cock for drawing off the evaporated gelatinous solution.

The wooden box *f′*, Fig. 30, a ground-plan of which is shown in Fig. 35, serves for the reception and settling of the evaporated gelatinous solution. Its bottom is constructed in a manner similar to that of the box *e′*.

The cock *n′*, which is placed 14 millimeters (0.55

Fig. 35.

inch) above the bottom of the box, serves for running the gelatinous solution into the wooden cooling boxes.

Preparation of the Bones.

The bones as received in the factory are sorted by throwing out the spongy material, etc. They are then steeped in lime-water for a few days to free them from adhering particles of flesh, after which they are dried and stored away for future use.

Reduction of the Bones.

The boiler *a*, is filled two-thirds with water, and heated until the manometer indicates a pressure of 30°. In the mean while the drum *e*, is filled seven-eighths with perfectly dry bones, and steam is then admitted from the boiler *a*, through the graduated cock *y*. The fact that the bones in the drum are exposed to the proper temperature of 250° F. is recognized by the thermometer *b'*, placed between the cock and the drum.

To prevent the stagnation of the steam in the drum, a small jet of it is allowed constantly during the operation to escape through the cock *x*. The cock must

not be opened wider than is necessary to keep the temperature at 250° F. By opening it wider, this degree would be exceeded, and the gelatine-yielding substance would, in consequence, undergo alteration. A quarter of an hour after admitting the steam into the drum, the cock *t*, is opened, and again closed after allowing a small portion of the condensed steam to escape to the cock *u*, and, through this, into a box. This operation is repeated every quarter of an hour.

To change the position of the bones, the drum is revolved twice every half hour, by means of the gearing *q*, of course closing the cock *x* during the operation.

By carefully following the above rules, the bones will be thoroughly reduced in four hours. If, for instance, steam has been introduced into the drum at 5 o'clock A.M. the operation will be finished at 9 A.M. The cock *y*, is then closed, and the steam allowed to escape through the cock *x*. After the escape of the steam, the drum is emptied, by removing the lid and turning it upside down. It is then refilled with entirely dry bones, and the operation continued in a like manner, day and night, if necessary.

Extracting the Jelly.

After the bones have been taken from the drum, they are spread out under a shed, and, when dry, ground in a suitable mill. The resulting flour, which contains the jelly-yielding substance, is brought into

the vessel d', which, in the mean while, has been furnished with sufficient water to cover the flour 65 centimeters (25.59 inches) deep. The mixture is boiled for three-quarters of an hour, being constantly stirred to prevent the flour from forming a heavy and dense mass which would hinder the quick extraction of the jelly. Ebullition is then interrupted by closing the cock h, and the fat floating on the surface skimmed off. After allowing the gelatinous solution to settle, it is drawn off by means of a faucet placed above the level of the flour. 30 bucketfuls of the gelatinous solution are then at once poured into a vat and mixed with the condensed steam drawn off by means of the cocks t u, during the reduction of the bones in the drum. After allowing the mixture to cool to 160° to 155° F., 20 kilogr. (44 lbs.) of pulverized alum are added at once and as quickly as possible. When the gelatinous solution has become transparent, it is drawn off into the box e', and a few bucketfuls of hot water are poured upon the sediment in the vat in order to extract the remaining jelly, which is effected by thorough stirring and allowing to settle until the water is entirely clear.

Evaporation of the Gelatinous Solution.

After disposing of the 30 bucketfuls in the manner mentioned, the remainder of the gelatinous solution is evaporated. This is accomplished in the box e', which is filled 8 centimeters (3.15 inches) deep

with gelatinous solution, and steam is then admitted into the tubular bottom pieces. To promote evaporation and keep the fluid constantly in motion, the cock *i′* is only opened far enough to keep up gentle ebullition. During evaporation the solution should be frequently stirred with an implement resembling a rake. The nearer the required degree of concentration is approached, the greater care must be exercised to prevent the solution from boiling too strongly. The proper degree of consistency is obtained when half a saucer full of the solution placed in a shady place in the air acquires in a short time such a consistency that, when touched with the finger, no impression remains. The cock *i′* is then closed, and the jelly is drawn off into the box *d′*, which contains the 30 bucketfuls of clarified jelly, care being had to mix the two solutions as quickly as possible. After evaporating all the gelatinous solution and mixing it in the box *d′*, the whole is heated to 158° F., by admitting steam through the cock *k′*, care being had not to forget closing it as soon as the above temperature has been reached. The solution is then thoroughly stirred and permitted to settle for three hours to allow of the precipitation of the lime salts decomposed by the alum. The fluid, which is now perfectly transparent and of a beautiful dark-yellow color, is then drawn off into wooden cooling boxes 2 to 2.5 meters (6.56 to 8.2 feet) long, 20 centimeters (7.87 inches) wide, and 16 centimeters (6.30 inches) deep. The following day the gelatine is cut into leaves 25 centimeters (9.84

inches) long and 12 centimeters (4.72 inches) wide, which are dried upon nets. When quite dry, the drying process is finished by bringing the leaves into the drying-room which is heated by the pipe *g*. (Fig. 30.)

The bone flour remaining in the box *d′* still contains much jelly, which is extracted by pressure. This is accomplished immediately after running off the gelatinous solution into the evaporating vessel. The liquid which has drained through the cloth frame previously mentioned, is drawn off by opening the cock *p′*, Fig. 33, while the residue in the box *d′* is placed in coarse bags and the jelly extracted by subjecting the bags to strong pressure under an iron screw-press. Before mixing the extracted fluid with the solution in the evaporating vessel, it is recommended to allow it to settle, as it is always more or less turbid. The residue remaining in the bags is an excellent manure.

The modern process of preparing gelatine, which is now in almost general use, is as follows: Bones of all sizes, in quantities of about 100 cwt., are exposed to the action of the sun and air for six weeks, and during dry weather moistened with water several times daily. They are then taken in lots containing from 10 to 15 cwt. and put into vats and treated with solution of hydrochloric acid of about 4° B. until they become soft and pliable.

For gelatine to be used as an article of food, or for medicinal purposes, only the purest hydrochloric acid obtainable should be used, while the ordinary article suffices for that for technical purposes.

The use of an apparatus with rarefied air for reducing the bones, or that of bisulphide of carbon in an apparatus similar to that used in oil mills, deserves consideration where the manufacture is carried on on a large scale.

The now soft and pliable bones are washed in fresh water and then put into lime-water, where they are allowed to remain for fourteen days, after which they are taken out and again well washed in fresh water, and laid out to dry in the air. This process produces what is called "raw gelatine."

The preparation of the finished gelatine demands still more labor and care. A quantity containing, for example, 500 lbs. of raw gelatine, is placed in running water for 24 hours, which renders the mass soft and easily broken up, when it is left for several days exposed to the open air. It is then put into a boiler similar to those described for the manufacture of glue, and the gelatine extracted either by boiling with water, or introducing steam. After this cooking or digesting, the proper length of time being determined by the state of the mass, the solution is treated in the same manner as glue, *i. e.* it is either poured into shallow vessels of tinplate or upon slabs of marble, slate, or compact stone to solidify, and then cut, and dried upon nets.

As will be seen from the foregoing, the manufacture of gelatine does not differ materially from that of glue except that the most suitable raw material is carefully selected and scrupulously cleansed, freed from fat, and

the resulting gelatinous solution properly strained. If, notwithstanding these manipulations, the resulting jelly is not entirely pure, it must, after solidification, be washed with pure water until the latter runs off entirely free from taste and odor.

In some factories the following process is observed: The gelatinous solution drawn from the extracting vessel is put into a vat containing three gallons of fresh water impregnated with sulphuric acid. This is stirred, two quarts of acetic acid are added, and the mass is left to stand for one hour, when it is filtered through a linen cloth, and put into wooden cooling boxes. Before becoming thoroughly hard, it is cut by a machine into thin sheets and laid out to dry under a shed in an airy and dry situation. This process, it is claimed, will produce a quality of gelatine which for beauty and value is not equalled by that made after any other method.

Impure glue can be converted into gelatine by allowing it to swell in ordinary vinegar, and, after pouring off the excess of vinegar, washing carefully and melting the jelly at a gentle heat.

We give in the following the mode of manufacture as carried on in some well-known factories.

Fabrication of Gelatine according to Dr. Schwarz.

After freeing the bones from fat, they are broken into coarse pieces and treated with hydrochloric acid

three times in succession. The acid, of which 5 per cent. is used in summer, and 6 per cent. in winter, dissolves the calcium phosphate in the bones, while it does not attack the cartilaginous tissue. The last acid, which is not thoroughly exhausted, is poured over fresh bones. For 50 kilogr. (110 lbs.) of bones, 50 kilogr. (110 lbs.) of crude acid of 20 per cent. are generally required. After washing the cartilaginous tissue with water, it is treated with weak milk of lime in order to remove the last traces of acid. The bones are then brought into a tall iron boiler, and, after adding an equal weight of water, heated to the boiling point. After digesting for a proper length of time, the lime-soap floating upon the surface is skimmed off, and the solution left to settle, after which it is drawn into a wooden vat surrounded with a bad conductor of heat. The solution is clarified by adding 0.2 per cent. of alum, and is then poured into wooden cooling boxes where it solidifies in 24 hours.

After detaching the cubes of gelatine from the sides of the boxes by means of the broad blade of a knife, they are cut by a machine into thin sheets and laid upon cord nets and dried in the air. As this can only be done in summer the manufacture is necessarily restricted to this time of the year. The gelatine obtained by this process is very white, perfectly transparent, difficult to break, and, if properly treated, possesses extraordinary adhesive power.

By compounding the acid solution of phosphate of lime with whiting, it is precipitated, while the chloride

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of lime remains in solution, and yields, after compounding with solution of ammonium carbonate, such as is obtained in distilling bones, sal ammoniac, and very finely divided carbonate of lime. By compounding the phosphate of lime with sulphuric acid, gypsum and superphosphate of lime are obtained. By mixing the solution of the latter with pulverized charcoal, and after evaporating to dryness, heating the mixture to a red heat, in order to expel all moisture, and then heating to a white heat in clay crucibles, phosphorus is obtained, of which large quantities are manufactured in the factory where the above-described process is in use.

Jullion's and Pirie's Method of Preparing Bone-Glue.

The cleansed bones are sorted by separating the denser and heavier ones from the more spongy and lighter. Each variety is then broken into suitable pieces and placed in a vessel, and solution of hydrochloric acid poured over them so as to cover them completely. After closing the vessel hermetically and exhausting the air, the heavy bones are left to macerate for 48 hours, while 24 hours suffice for the light material. By this treatment the calcium and alkali are entirely extracted from the bones, while the cartilaginous tissue remains behind, which is then further worked in the ordinary manner.

For heavy bones a solution of hydrochloric acid of

1.035 specific gravity is used, while for light bones one of 1.015 to 1.0175 specific gravity suffices. The strength of the acid must altogether be regulated by the density of the bones, and should be so calculated that all the calcium and alkali are extracted from the bones without the use of an excess of acid. For 50 kilogr. (110 lbs.) of heavy and solid bones an average of 458 liters (121 gallons) of the above strength will be required.

In conclusion, we give a new process of manufacturing bone-glue, which is the invention of R. Hagen and F. Seltsam, and is patented in Germany. Seltsam's method of extracting the fat from bones by means of benzine, we have given in a former chapter, to which we refer the reader.

Hagen's and Seltsam's Process of Preparing Bone-Glue.

The bone-glue is prepared either from bones comminuted to the size of grits or from offal produced in the manufacture of bone meal. The material is wet with an aqueous solution of oxalic acid, and, after heaping in a pile, allowed to rest, whereby spontaneous heating takes place. It is then steamed in a glue boiler with open manhole. After expulsion of the ammoniacal combinations, a pressure of from 2 to 3 atmospheres is given. To dissolve the jelly completely, boiling water is from time to time pumped in. The concentrated gelatinous solution, which contains

from 25 to 30 per cent. of dry substance, is finally pressed into a wooden pan, where it can be further concentrated by heating a serpentine pipe. The entire operation is finished in five to six hours.

VI.

USES OF GLUE AND GELAT NE.

An inquiry into the various technical uses of glue and gelatine must be of interest to the manufacturer, so as to enable him when acting, as is frequently the case, as salesman, to know to whom to offer his product; and also to learn what special demands he has to satisfy, as not every glue is adapted to every purpose, different qualities being required for special uses.

1.—Use of Glue as a Cement.

In the first chapter, treating of the question "What is Glue?" we drew special attention to the fact that the adhesive power of glutin is greater than that of chondrin; and that glutin prepared from skin and tendons possesses the adhesive power in a still higher degree than glue prepared from bones. This is the reason why good sound glue made from scraps of skin is preferred by those artisans who may be considered the principal consumers, such as cabinet-makers, carpenters, turners, book-binders, etc. We do not, how-

ever, wish to be understood as meaning that good bone-glue cannot be used for the same purposes, for we are well aware that, especially in modern times, much bone-glue of excellent quality and at a low price is brought into the market by manufacturers of animal charcoal and bone-meal, and is used in gluing wood, etc.

Glue suitable as a cement for the above purposes should be of an amber or brown-yellow color, transparent or translucent, clear, dry, and hard, and with a glassy fracture which should not be brittle but somewhat elastic. Placed in cold water, it should swell up and absorb as much of it as possible without actually dissolving even if it remains there for 48 hours. The supernatant water should be free from a putrid odor and contain but a small quantity of foreign substances in solution. Such glue will entirely dissolve on heating to 50° R. (62.5° C., 144.5° F.). Heating to a higher temperature should be avoided.

2.—Use of Glue as an Agglutinant.

Glue solution is used for holding together pulverulent substances, such as mineral colors in the manufacture of colored paper and paper-hangings, in the ground of the gilder, or it is mixed with plaster of Paris or chalk for the manufacture of plastic masses which become hard on drying. Generally speaking, it is best to use only good sound glue for these purposes, though it may sometimes be possible to use defective and

cheap varieties without injurious consequences. For color mixtures the glue should at all events be free from acids and alkalies, as they exert a decomposing and altering influence upon the colors. The gilder should always use the best quality of glue, as otherwise the work he applies later on to the ground will spoil.

3.—Glue in Sizing and Dressing.

The principal object of sizing goods is to impart to them a certain degree of stiffness, to give them a good appearance, and make them pleasant to the touch.

As glue would injure the color of white goods, it cannot be used for sizing them, but, on the other hand, much is employed for preparing size for the use of hat and cloth manufacturers, weavers, etc. Before the introduction of the paper machine and invention of rosin glue, animal glue was exclusively used for sizing paper, but at present it is only used for sizing paper manufactured from rags, and for pasteboard, and also by manufacturers producing drawing paper sized with animal substances. The paper, after leaving the machine, is passed through a glue solution and then dried in the air.

For actual sizing purposes good and fine varieties of glue are only used, or sometimes the manufacturers prepare their own size by boiling to glue dried calves' heads, or rabbit skins deprived of their fur, scraps of parchment, etc. For cheap woollen hats, glue is used

instead of shellac. The cloth manufacturer procures his glue mostly in the form of a jelly.

We will later on give receipts for preparing several kinds of size and also substitutes.

4.—Glue for Culinary and Medicinal Purposes.

The use of glue for the above purposes is based upon three properties:—

1. Upon its power of coagulating and inclosing, while in this state, substances mechanically dissolved and finely divided in the fluid, which, being specifically as heavy as the fluid itself, cannot be removed by settling. The glue in this case acts as a clarifyer.

Large quantities of isinglass and gelatine specially prepared for the purpose, are used for clarifying and fining beer, wine, and other liquids, and for preparing jellies. Barclay, Perkins & Co.'s brewery in England consumes 120 lbs. of isinglass daily for clarifying porter. The material to be used for jellies and other culinary purposes must, of course, be colorless and entirely free from odor. Jellies are made palatable by flavoring with spices, sugar, essences, etc., before congealing. A vegetable gelatine, of which we will speak later on, has recently been introduced from China, and being cheaper and better and entirely odorless, and yielding more and better results, threatens to become a dangerous rival of isinglass and gelatine.

Before the introduction of Liebig's beef extract, for the manufacture of which 100,000 cattle are yearly killed in Fray Bentos in South America, bouillon tablets, consisting of a mixture of bone jelly, meat broth, extract of pot-herbs, and flour or starch, were largely used. 50 kilogr. (110 lbs.) of meat repeatedly boiled yield 2.5 kilogr. (5.5 lbs.) of bouillon tablets.

A good meat broth, though not equal to that from Liebig's extract, is obtained from these tablets by an addition of 30 times their weight of water.

2. Glue dissolved in water gelatinizes at an ordinary temperature, and on mixing with other liquids, such as meat broth, fruit jellies, and essences, which are to be used as food, causes their solidification.

3. Glue acts as a healing agent by preventing the access of air to wounds. Court plaster is prepared from gelatine. When cabinet-makers cut themselves, they apply glue to the wound with the best success. In hospitals a compound of gelatine and glycerine is used as the best means of closing wounds, the same compound having also been successfully used for preserving articles of food such as eggs, fruit, and even meat.

Every good quality of glue can be used for the above purposes.

Medicines of a disagreeable taste are frequently inclosed in gelatine capsules, so that they can be taken without causing inconvenience to the patient. The use of these capsules has grown to such an extent as to form

a special branch of industry.* We will later on describe the mode of manufacturing them.

5.—Use of Glue for Elastic Masses and as a Partial Substitute for Caoutchouc.

As previously mentioned, glue mixed with glycerine forms an elastic mass resembling caoutchouc. The same effect can be produced by an addition of molasses. This elastic mass, of the preparation of which we will speak later on, is of great importance for the manufacture of printer's rollers, for moulds, for plaster of Paris casts, etc. Some glue manufacturers prepare this mass ready for use, so that the printer or lithographer need only remelt it and cast it in a mould.

Glue is of great importance in photo-lithography, as, mixed with chromium salts, it is the only known means of transferring a photographic negative to the stone. In photography gelatine is used for negative pictures upon glass. For the manufacturer of casts of plaster of Paris or cement, this glue mass, which is generally used without an addition of glycerine, is indispensable for making moulds.

Glue mixed with glycerine is much used as a substitute for caoutchouc in manufacturing toys for children, such as dolls' heads, animals, etc. For these purposes it is recommended to select glue which forms a very

* A factory in Danzig, Prussia, turns out three millions of these capsules every year.—W. T. B.

solid jelly even if it possesses but little adhesive power, pure bone glue being the best.

Glue is used for the manufacture of windows for war-vessels, as the concussion caused by the firing of heavy guns would break glass windows. To obtain these windows of great transparency, dip brass wire netting stretched upon a wooden frame in a hot solution of gelatine of the finest quality, and after allowing the first coat to dry somewhat, repeat the operation until the window has acquired the desired thickness. To protect it against moisture varnish the outside.

6.—Use of Glue for Fancy Articles.

Great progress has lately been made in the use of glue, that is gelatine, in the manufacture of fancy articles.

The best known of all these products are perhaps the gelatine foils. They are thin, transparent sheets brilliantly colored, and are used for printing sacred images, visiting cards, labels, etc.

Gelatine veneers were first shown at the Paris International Exhibition. They consist of sheets varying in thickness, which have been deprived of their translucency by an admixture of colors in imitation of various crystallizations of salts, and such stones as lazulite, malachite, and avanturine. Glue imitations of mother of pearl, tortoise shell, and ivory were shown which closely resembled the genuine articles. These veneers have been largely introduced in the manufacture

of fancy articles, cabinet ware, buttons, etc. The most brilliant use to which they have been put is in the manufacture of fans for which ivory and tortoise shell were formerly used, and there are perhaps few ladies who know that these glittering toys are manufactured from horse bones.

The successful introduction of glue veneers was soon followed by a substitute for horn in general, and combs, buttons, snuff-boxes, and hundreds of other fancy articles are at present manufactured from these imitations.

In the foregoing statement we have only enumerated some of the principal uses of glue, and there can be no doubt that with an increasing knowledge of its nature and properties, a wide field is still open for progress in this industry.

VII.

DIFFERENT VARIETIES OF GLUE AND GELATINE, AND SPECIAL DIRECTIONS FOR THEIR PREPARATION.

Joiner's Glue.

The principal requisite of this variety, which is without doubt the oldest in use and most in demand, is great adhesive power. It is used for joining wood,

leather, paper, etc., and varies very much in quality and price.

The best variety is prepared from scraps of hide and skin. A light color not being especially demanded, there existing rather a prejudice in favor of a dark colored article, waste of cattle and horse skins and tendons can be used for its manufacture.

Joiner's glue, which is generally preferred in thin cakes, is chiefly manufactured in regular glue factories, though to be able to compete with the bone-glue turned out by the large establishments, the glue-boiler generally mixes skin and bone-glue, and is thus enabled to turn out a tolerably good quality. The price paid for the different varieties of joiner's glue varies very much, being generally higher in winter than in summer, and is frequently more regulated by the external appearance of the article than by its actual value. Glue without gloss, very much warped and of a very dark color, may, notwithstanding its faulty appearance, possess excellent qualities.

Nothing need be said about the manufacture of joiner's glue, since what has been said about the manufacture of glue in general suffices for the purpose.

How to make and use Glue.

Break the glue into small pieces, put it into an iron kettle, cover the glue with water and allow it to soak twelve hours; after soaking boil until done. Then pour it into an air-tight box ; leave the cover off

until cold, then cover up tight. As glue is required, cut out a portion and melt in the usual way. Expose no more of the made glue to the atmosphere for any length of time than is necessary, as the atmosphere is very destructive to made glue.

All glue, as received from the factory, requires the addition of water before it will melt properly, and every addition of water (while the glue is fresh made) will, up to a certain point, increase its adhesiveness and elasticity. Some glues will bear more water than others ; but all will bear more water than usually falls to their share, and that, too, with a greater improvement in the quality of the work. For glue to be properly effective, it requires to penetrate the pores of the wood, and the more a body of glue penetrates the wood the more substantial the joint will remain. Glues that take the longest to dry are to be preferred to those that dry quickly, the slow-drying glues being always the strongest, other things being equal. Never heat made glue in a pot that is subjected to the direct heat of the fire or a lamp. All such methods of heating glue cannot be condemned in terms too strong. Do not use thick glue for joints or veneering. In all cases work it well into the wood in a manner similar to what painters do with paint. Glue both surfaces of your work excepting in the case of veneering. Never glue upon hot wood, as it will absorb all the water in the glue too suddenly, and leave only a very little residue, with no adhesiveness in it whatever.

Holding Power of Glue.

1. Glue exerts a far greater hold on surfaces of wood cut across the grain than on those that have been split, or cut with the grain.

2. When two surfaces of split wood are laid together, the hold of the glue is the same, whether the fibres are laid parallel or crosswise to each other.

3. The holding power of glue on different woods estimated in kilogrammes per square centimeter (0.155 square inch) is as follows:—

	Cut across the grain.	Split.
Beech,	155 55 (342.21 lbs.)	78.83 (173.42 lbs.)
Hornbeam,	126.50 (278.30 ")	79.16 (174.15 ")
Maple,	87.66 (192.85 ")	63.00 (138.6 ")
Oak,	128.34 (282.34 ")	55.16 (121.35 ")
Fir,	110.50 (243.10 ")	24.16 (53.15 ")

Cologne Glue.

The variety of glue known under this name is prepared from selected scraps of hide and skin, and is consequently very pure, and possesses great adhesive power. It is of a light-brown color, and comes into commerce in short thick cakes of great hardness. It is an excellent quality of glue, and is preferred to all others by bookbinders, workers in leather, etc. There are many imitations of this variety, bone-glue being frequently sold as Cologne glue.

The genuine article is manufactured from refuse of hide, which, after liming, is carefully bleached in a

bath of chloride of lime, the concentration of which depends on the darker or lighter color of the glue stock. For 100 kilogr. (220 lbs.) of glue stock, it is generally customary to use 0.5 kilogr. (1.1 lb.) of chloride of lime mixed with sufficient water to cover the stock.

After thorough impregnation of the glue stock, which generally requires about half an hour, add sufficient hydrochloric acid to impart an acid taste to the bath of chloride of lime. To be able to mix the mass thoroughly, it is best to use a vat provided with a stirring apparatus. After allowing the acid to act for a quarter of an hour, remove every trace of it by careful washing.

To obtain a jelly as clear as possible, the gelatinous liquor is drawn off as soon as the thin portions of the glue stock and the outside of the thicker ones are dissolved, they being more thoroughly bleached than the rest. The residue is worked into a darker glue.

Russian Glue.

This variety is of a dirty white color, and, like Cologne glue, is brought into commerce in short, thick cakes. Its color and opaqueness are imparted to it by an addition of 4 to 8 per cent. of white lead, chalk, zinc white, or permanent white (sulphate of baryta). It has been claimed that the superior adhesive power of Russian glue is due to this addition of mineral substances, but many experiments made by us fail to substantiate this claim. In case the glue turns out

turbid, it may be of advantage to make it opaque by an addition of coloring matter, but the quality of the glue remains unchanged. The best time to add the coloring matter is shortly before drawing the jelly from the settling vats into the cooling boxes, as the jelly is then of sufficient consistency to prevent the substances from settling on the bottom. Skin-glue, as well as bone-glue, is sold under the name of Russian glue.

Patent Glue

Is a very pure variety of bone-glue of a deep dark brown color. To satisfy the demand for thick cakes, they must be cut from very concentrated jelly to insure their drying. As a rule, the cakes do not show the impressions of the nets. Patent glue is very glossy, and swells up very much in water. It is much liked, and is in great demand, especially in France. It fully deserves its good reputation, since it consists of the first and purest solution drawn from the boiler, and has been less exposed to the heat, and contains more glutin than the succeeding runs. At the last Vienna Exhibition a French manufacturer exhibited this variety of glue in cakes 1 meter (3.28 feet) long, 0.25 meter (9.84 inches) wide, and 0.01 meter (0.39 inch) thick.

Gilder's Glue.

This variety is of a very pale yellow color, and comes into commerce in very thin cakes tied up in packages weighing 1 kilogr. (2.2 lbs.) each. It is a variety of skin-glue bleached with chloride of lime, and is difficult to dissolve in water. Only the liquor first drawn off is used for its manufacture.

A very superior article of gilder's glue is obtained by cutting rabbit skins into fine shreds, and boiling in water, then turning the mixture into a basket through which the liquid passes, leaving the refuse behind. About 100 grammes (3.52 ozs.) of sulphate of zinc and 20 grammes (0.705 ozs.) of alum are then separately dissolved in pure boiling water and poured into the first-mentioned liquid, and the whole well stirred together while hot. The mixture is then passed through a sieve into a rectangular box in which the jelly remains twenty-four hours in winter, or about forty-eight in summer. The solid mass is taken from the box, cut into slices of proper thickness, and dried upon nets.

Size Glue and Parchment Glue

Are manufactured in the same manner. Both are skin-glues, and can be readily produced by following the directions in the first part of this work.

The so-called *Paris glue* is a variety used for sizing. It is brown, opaque, and almost always soft.

Being very hygrometric, and imparting a suitable flexibility to the felt, it is better adapted for hatter's use than any other variety. For its manufacture only the generative organs, or the thick tendons of the legs of cattle and horses, are used, or other waste and fleshy parts, and substances mixed with small bones, which, if thoroughly cleansed, might yield a good quality of glue, but are intentionally transformed by too long-continued boiling, whereby the gelatinous solution is largely deprived of its adhesive power, and yields a hygrometric product.

A *new glue size* for paper-makers' use, which is nearly 50 per cent. cheaper than the old kinds and more suitable for the purpose, is prepared as follows: Dissolve in a copper pan heated by indirect steam 20 to 22 kilogr. (44 to 48.4 lbs.) of soda in 90 to 110 kilogr. (198 to 242 lbs.) of boiling water; then add, stirring constantly, 140 kilogr. (308 lbs.) of powdered rosin, keeping the whole boiling continually until all the rosin is dissolved, which is generally accomplished in three to four hours. The soda-rosin composition is mixed together with a glue solution made by dissolving 50 kilogr. (110 lbs.) of glue in 140 to 150 kilogr. (308 to 330 lbs.) of water. Boil both solutions together for about ten minutes, after which run the mixture through a fine sieve or filter, and it is then ready for use. The best proportions for mixing the vegetable and animal sizes are, for one and a half parts of rosin, add one part of glue, or for some purposes equal parts of each can be taken. An addition of starch, if required, can

be made as usual, also the mixing of this improved size with the pulp.

New Substitute for Glue-Size.

The following preparation, which is odorless, neutral, and suffers no change, is the invention of H. R. P. Hosemann, of Berlin, and is patented in Germany. To prepare it stir together 50 kilogr. (110 lbs.) of solution of calcium chloride of 30° to 32° B., 25 kilogr. (55 lbs.) of potato starch, and 25 kilogr. (55 lbs.) of water. Then add 5 kilogr. (11 lbs.) of a solution of colophony in a mixture of equal parts of potash and soda lye of 28° to 30° B. and heat, with constant stirring, to 50° to 60° R. (62.5° to 75° C.; 144.5° to 167° F.) and add 4 kilogr. (8.8 lbs.) of a mixture of 60 parts of prepared tartar (10 per cent.), $127\frac{1}{2}$ parts of sulphuric acid of 10° B., and $10\frac{1}{2}$ parts of solution of sulphate of alumina of 9° B., stirred together in 40 kilogr. (88 lbs.) of water. Finally add, with constant stirring, 1 kilogr. (2.2 lbs.) of chloride of zinc solution of 10° B. in 5 kilogr. (11 lbs.) of water and 200 grammes (7.05 ozs.) of phenol and 30 grammes (1.05 oz.) of nitro-benzole in 4 to 5 kilogr. (8 to 11 lbs.) of water.

The mass is used as a substitute for weaver's size, for the glue and gum preparations in the manufacture of paper-hangings and colored papers, for stiffening in the manufacture of felt, and as an inspissation in calico printing and as a paste.

In using the preparation for vegetable fibre and as a dressing, the colophony is omitted.

To impart to the preparation bleaching properties the colophony, the preparation of tartar and sulphate of alumina, and the chloride of zinc are omitted and 0.5 to 1 kilogr. (1.1 to 2.2 lbs.) of permanganate of potash substituted for it, or the chloride of zinc is retained and 4 to 8 kilogr. (8.8 to 17.6 lbs.) of bisulphate of soda are added.

For preparing the size a stirring apparatus is used whose vertical hollow shaft is provided with horizontal, hollow, and perforated arms, upon which sit sheet-iron prisms perforated and movable. In revolving the shaft, steam passes through the arms and enters the mass through the revolving sheet-iron prisms.

Parementine or Poliocolle.

A new size recently brought into commerce under the above name is prepared by dissolving 100 parts of gelatine in as little water as possible, and compounding the solution with 70 parts of dextrine, 20 of glycerine, 20 of Epsom salts, and 20 of white vitriol. It is used for linen and woollen goods.

New Size.

Heat to the boiling point a sufficient quantity of water to dissolve 100 kilogr. (220 lbs.) of starch, and add 100 kilogr. (220 lbs.) of magnesium chloride,

and, after drawing off the clear fluid, 1 kilogr. (2.2 lbs.) of hydrochloric acid. Then add the starch, and bring the whole to the boiling point. After keeping the mixture at 90° C. (194° F.) for about one hour, add clarified lime-water until neutral reaction takes place, and then repeat the boiling. By this process an artificial glue is obtained, which can be kept by pouring it into moulds and allowing it to solidify.

Manufacture of Glue-Size.

The glue used by manufacturers and in other various branches has the disadvantage that if diluted, it will very soon become mildewed and rotten, will smell badly, and decompose, especially in a warm climate.

The object of this new process, which is the invention of G. J. Lesser, of Frankfort, Germany, is to produce a size of very consistent form, and this strong consistency is effected by adding several chemicals at certain stages and temperatures, which will prevent the bad smell, and always remain so free from smell, and will also preserve it in any climate when stored away. The substances used for this size are as follows: glue (sometimes a clear white gelatine), water, sulphate of alumina, alum, ammonia (lump), sulphate of magnesia, chloride of zinc, nitro-benzole, and carbolic acid. Take a quantity of glue, according to the strength required for the various branches, put it to soak in water, which previously boil for two hours, in

order to annihilate any animalculæ contained therein, and use it cold. After being soaked for about twenty-four hours, melt it in a copper boiler by a slow fire or steam, and add a solution of sulphate of alumina and alum. This solution consists of three parts of sulphate of alumina and one part of alum, which when very clear must be 3° Baumé. The latter must be thoroughly combined with the melted glue. Then add the nitro-benzole and carbolic acid, which are also previously combined together (in equal parts), and mix it in well. Then add chloride of zinc, in which pour the magnesia, and mix the whole. When thoroughly combined, immediately remove it into wooden vessels and let it cool off.

The water, used in the manner as above described, is a preservative by itself for the melted size. The sulphate of alumina, with the small proportion of alum, hardens the substance. The nitro-benzole and carbolic acid mixed together, and of which there is only a very small quantity used, do not allow any mildew. The chloride of zinc, together with the sulphate of magnesia, prevents the smell in one way. On the other hand, it does not allow the size to dry away, and keeps the same always fresh in any atmosphere.

The following formula, giving quantities of the materials to be used, has been found to give good results: thirty pounds of glue, eleven pounds of sulphate of alumina, three pounds of ammonia (lump), three pounds of chloride of zinc, two pounds of sulphate of magnesia, one-half ounce of nitro-benzole, one-half

ounce of carbolic acid, and fifty-one pounds of water. This can be varied by using gelatine instead of glue, or by using equal proportions of glue and gelatine.

Liquid Glue.

For many purposes it is of advantage to have the glue in a liquid form without first being obliged to heat it. By dissolving glue in its own weight of water, and adding a small quantity of nitric acid, it loses its property of gelatinizing without injury to its adhesive power.

In the following we give a few receipts for keeping glue solutions liquid:—

1. Dissolve 38 parts of glue in small pieces in 100 parts of acetic acid. Solution is promoted by exposing the vessel to the sun, or placing it in hot water.

2. Dissolve 1 kilogr. (2.2 lbs.) of glue of a good quality in 1 liter (2.11 pints) of water, and add gradually 100 grammes (3.52 ozs.) of nitric acid of 36° B. This will produce effervescence and development of yellow vapors. The glue is ready after the liquid has become quiet and cold.

3. An excellent liquid glue is made by dissolving glue in nitric ether. The ether will only dissolve a certain amount of glue, consequently the solution cannot be made too thick. The glue thus made is about the consistency of molasses, and is doubly as tenacious as that made with hot water. If a few bits of India rubber cut into scraps the size of a buck shot, be

added, and the solution allowed to stand for a few days, being stirred frequently, it will be all the better, and will resist the dampness twice as well as glue made with water.

4. Another variety of liquid glue is prepared by dissolving 3 parts of glue in small pieces in 12 to 15 of saccharate of lime. By heating the glue dissolves rapidly and remains liquid, when cold, without loss of adhesive power. Any desirable consistency can be secured by varying the amount of saccharate of lime. Thick glue retains its muddy color, while a thin solution becomes clear on standing.

The saccharate of lime is prepared by dissolving 1 part of loaf sugar in 3 parts of water, and after adding one-fourth part of the weight of the sugar of slacked lime, heating the whole to 65° to 85° C. (149° to 185° F.), and allowing it to macerate for several days, shaking it frequently. The solution, which has the properties of mucilage, is then decanted from the sediment.

The solution of the glue in saccharate of lime is readily accomplished, even old gelatine, which has become insoluble in water, dissolving without difficulty. This variety of liquid glue possesses great adhesive power, and admits of many uses.

5. A new method of preparing liquid glue is as follows: Dilute officinal phosphoric acid with 2 parts by weight of water and saturate with carbonate of ammonia. Dilute the resulting liquid, which should be still somewhat acid, with another part of water, warm

it on a water bath, and dissolve in it sufficient Cologne glue to form a thick sirupy liquid. Keep in well-stoppered bottles.

Steam Glue.

Under this name several varieties of liquid glue are brought into commerce. They are prepared as follows:—

1. *Russian Steam-Glue.* 100 parts of a good quality of glue, 100 to 110 parts of warm water, and 5.5 to 6 parts of commercial nitric acid of 36° B.

2. *Pale Steam-Glue.* 100 parts of glue, 200 of water, and 12 of nitric acid of 36° B.

3. *Dark Steam-Glue.* 100 parts of glue, 140 of water, and 16 of nitric acid of 36° B.

Soak the glue in cold water, then pour the necessary quantity of warm water over it, and heat gently on a water-bath until all the glue is dissolved. Next add gradually the nitric acid with constant stirring, and to the Russian steam-glue 6 parts of finely pulverized sulphate of lead, which will impart to it the white color.

Chrome Glue.

This preparation is very permanent and durable. To prepare it add to a moderately concentrated solution of 5 parts of glue 1 of dissolved acid chromate of lime, this salt being considered better for the purpose

than the bichromate of potash usually used. The glue thus prepared becomes, after exposure to the light, insoluble in water in consequence of a partial reduction of the chromic acid. This preparation can be used for cementing glass articles, liable to be exposed to boiling water, the treatment being the ordinary one of applying the glue to both surfaces of the fractured object, and then binding them together until dry, and exposing them for a sufficient length of time to the light, after which boiling water will have no effect upon them. It is suggested that this preparation is better adapted to cementing the covers on glass slides than any now in use. The same preparation can be applied for making fabrics water-proof, especially sails, awnings, etc., where no great flexibility is required. Two or three applications of the glue, either by immersion of the object in it, or by the use of the brush, will answer the purpose. Roofing paper is also rendered impervious, even when exposed to long-continued rains.

Glue for Attaching Leather to Metal.

A method of affixing leather to metal, so that it will split before it can be torn off, consists in digesting a quantity of nutgalls, reduced to powder, in eight parts of distilled water for six hours, and filtering it through a cloth; then dissolving one part by weight of glue in the same quantity of water, and allowing it to remain twenty-four hours. The leather is moistened

with the decoction of nutgalls and the solution of glue applied to the metal, previously roughened and heated. The leather is then laid upon it, and dried under pressure.

Glue for Leather, Paper, etc.

The following process affords an unusually adhesive paste, adapted to fastening leather, paper, etc., without the defects of glue ; and if preserved from evaporation in closed bottles, will keep for years. Cover 4 parts, by weight, of glue with 15 parts of cold water, and allow it to soak for several hours ; then warm moderately till the solution is perfectly clear and dilute it with 65 parts of boiling water, intimately stirred in. Next prepare a solution of 30 parts of starch in 200 of cold water, so as to form a thin homogeneous liquid free from lumps, and pour the boiling glue solution into it with thorough stirring, and at the same time keeping the mass boiling.

Glue for Parchment Paper in making Sausage Skins.

The supply of intestines soon being exhausted by the enormous quantity of pease-sausages manufactured for the German army during the Franco-German war, the necessity arose for a substitute. This consisted of a tube of parchment glued together. Millions of these tubes from Dr. Jacobsen's factory were tested by the

government, and found to answer the purpose admirably. They were even boiled for hours without either the glued seam or the paper itself being injured by the operation. The secret of the composition of the glue employed for fastening the parchment paper seems to be well kept, but the one given in the following is equal to it in all respects, if not indeed identical. Add to one quart of a good adhesive solution of glue 20 to 25 grammes (0.705 to 0.88 oz.) of finely powdered bichromate of potash. Warm the mixture slightly on a water-bath when about to use it, and before applying it moisten the parchment paper. The latter, when glued with this preparation, as in the formation of the small cylinders for sausages, must be rapidly dried on a hurdle, and then exposed to the light until the yellow glue becomes brownish. The cylinders are then slowly boiled in a sufficient quantity of water to which two or three per-cent. of alum has been added, until all the chromate is dissolved out; and they are then washed in cold water and dried, and will look very inviting especially if white glue has been used. A similar result may be reached by using a concentrated solution of cellulose in ammoniacal oxide of copper. Thus, if cylinders of unsized paper are formed with this paste, and when thoroughly dry, drawn through a parchmentizing solution (a cooled mixture of 2 volumes of fuming sulphuric acid and 1 volume of water), they will be beautifully parchmentized, and after the neutralization of the acid, washing, etc., it will present a striking resemblance to natural intestines.

Tungstic Glue.

This preparation offers an acceptable substitute for hard Indian rubber. It is made by mixing a thick solution of glue with tungstate of soda and hydrochloric acid, by means of which a compound of tungstic acid and glue is precipitated, which, at a temperature of 30° to 40° C. (86° to 104° F.), is sufficiently elastic to admit of being drawn out into very thin sheets. On cooling, this mass becomes solid and brittle, and on being heated is again soft and plastic. It can be used for all purposes to which hard rubber is adapted.

Indestructible Mass for the Manufacture of Ornaments, Toys, etc.

A mass, which is to have the hardness of horn, consists of 50 parts of glue, 35 of wax or rosin, 15 of glycerine and the required quality of a metallic oxide, or mineral color. A soft mass consists of about 50 parts of glue, 25 of wax or rosin, and 25 of glycerine. The glue is melted in the glycerine with the assistance of steam, and the wax or rosin added. The latter in melting mixes with the glue and glycerine, and finally the mineral color is added. The mass is poured in a liquid state into moulds of plaster of Paris, wood, or metal. The degree of hardness of the mass is increased by an addition of 30 to 35 per cent.

of zinc white, or other mineral color, according to the coloring the article is to have.

Compound for Billiard Balls.

Allow 80 parts of Russian glue, and 10 of Cologne glue to swell up in 10 of water; then heat over a water-bath, and when dissolved add 5 parts of heavy spar, 4 of chalk, and 1 of boiled linseed oil. Of a portion of the mass form small sticks, dip them into the remainder, and allow the adherent portion to dry, and repeat this process until a crude ball has been formed. This is stored away in a dry room for three to four months, during which time it will dry out completely, and is then turned. The finished ball is placed in a bath of sulphate of alumina for one hour, dried, and polished like an ivory ball.

Mouth Glue.

Soak joiner's glue, broken into small pieces in cold water, for two days; pour off the supernatant water, and dissolve the jelly over a moderate fire. Then add to every 500 grammes (1.1 lb.) of glue, 250 grammes (8.81 ozs.) of fine white sugar, and stir thoroughly. Pour the mixture into suitable moulds and allow it to stand for a few days. In using it moisten the cake with the tongue.

WATER-PROOF GLUE.

Pulverize 1 part of good Cologne glue and dissolve the powder in 1 part of thick linseed oil varnish boiling hot and stir thoroughly. In using it heat the two planed surfaces of the wood to be joined, apply the glue warm, and subject the joined surfaces to pressure.

PROCESS OF COLORING GLUE.

Common black or dark glue, while possessing all the adhesive and other essential qualities of fine colored glue, has heretofore, owing to its color, been confined in its use to such purposes in the arts where color was not essential.

The object of the following process, which is the invention of G. J. Lesser, of Frankfort, Germany, is to color such glue so that it is both refined and tinted, and may be used for various purposes in the arts. It is especially applicable in the manufacture of sizing and finishing compounds for paper hangings, compounds for the manufacture of elastic rolls, for glue and size compounds for finishing yarns, textile fabrics of silk, cotton, etc., for the manufacture of calcimines and wall-coverings, for glue to be used with colored woods, and for all other purposes where a fine strong colored glue is required.

For coloring common black or dark glue take a pound and a half of liquid extract of lead and mix it into the water in which the glue has been soaked, as follows:—

thirteen pounds of glue, sixty-three and a quarter pounds of water. Allow the glue to soak for about twenty-four hours, then dilute it by a slow fire, and when heated gradually pour in one and a half pounds of the extract of lead and mix it well together.

The extract of lead is a well-known commercial article, and it is well suited for this purpose; but the inventor does not limit himself to this particular preparation, as there are a larger number of neutral and basic compounds of lead that may be so modified as to produce results similar, if not identical, with the results obtained by the formula above given. Gelatine may be treated instead of glue.

Prevention of the Cracking off of Glue.

The cracking of glue which frequently occurs when glued articles become very dry or are exposed to the heat of a stove, is prevented by an addition of chloride of calcium to the glue, which prevents its drying so completely as to become brittle. Glue thus treated will adhere to glass, metal, etc., and can be employed for affixing labels to bottles.

Glue for the Clarification of Wine and Beer.

Under this name a variety of glue in short, thick cakes of a dark yellow color has been recently introduced. It is cast in moulds engraved with the above inscription so as to appear in raised letters upon the

cakes. It is a carefully prepared horn glue, entirely tasteless and odorless, and answers the purpose of clarifying beer or wine as well as gelatine, but can be prepared much cheaper. The principal difficulty in manufacturing it is the thickness of the cakes, which may be overcome by using highly concentrated solutions, proper drying-rooms, and plaster of Paris moulds.

Gelatine Capsules for Medicinal Purposes.

Considerable use is made of gelatine in medicine. To destroy the disagreeable taste of some medicines they are either mixed with gelatine solution or inclosed in gelatine capsules. To prepare the latter, dissolve 8 parts of gelatine, 2 of sugar, and 1 of gum-arabic in 8 of water in a water-bath, and dip the pear-shaped ends of iron rods into the lukewarm solution. To facilitate the detaching of the gelatine film from the rods, grease the pear-shaped ends with oil. The capsules are dried by placing them in holes of a corresponding size in boards. When dry they are filled with the respective medicine, and closed with a drop of the same solution.

Court Plaster

Is made by brushing a thick solution of gelatine in warm water, and compounded with a little pure alcohol three times in succession over black or rose-colored

sarcenet stretched in a frame. When the last coat is dry, brush the whole over with tincture of Peruvian balsam.

Gelatine Veneers.

Franchi, as far back as 1814, prepared artificial ivory by mixing gelatine solution with earthy substances. This idea has been again taken up in modern times for the manufacture of veneers imitating not only ivory, but also avanturin, lapis lazuli, malachite, mother of pearl, and tortoise shell. These imitations are much liked by manufacturers of fancy articles, workers in leather, cabinet-makers, etc. They are prepared as follows:—

The process may be divided into five principal operations: 1. Preparation of the glass and marble plates; 2. Preparation of the glue solutions; 3. Pouring the colored solutions upon the plates; 4. Transferring the layer of glue to the layer of gelatine; and 5. Drying the veneers and detaching them from the plates.

1. *Preparation of the plates.*—Both marble and glass plates are used for imitations of marble, but glass plates only for imitations of mother of pearl. The glass plates must be ground, but need not exceed 3 to 4 millimeters (0.11 to 0.15 in.) in thickness, and only require careful washing and drying for imitations of mother of pearl. For imitations of marble they should be rubbed with an oiled linen rag. Other

glass plates, after being washed and polished with elutriated colcothar and water, are wiped with a soft rag to remove any particle of the polishing powder. The polished surface is then gently rubbed with a rag dipped in pure Spanish chalk, and the excess of chalk carefully dusted off.

2. *Preparation of the glue solutions.*—For one dozen plates, each 1 square meter (10.76 square feet) soak 900 grammes (1.98 lb.) of good, colorless glue in water for 24 hours, pour off the water and melt the glue in a water-bath and stir in 100 grammes (3.52 ozs.) of glycerine. For imitating marbles of two colors, compound 600 to 700 cubic centimeters (20.3–23.8 fluidounces) of this glue solution with the quantities of thoroughly ground mineral colors given below; the rest of the glue solution is mixed with 180 grammes (6.34 ozs.) of zinc white ground very fine. For imitating marble of three colors mix 400 cubic centimeters (13.8 fluidounces) of the glue solution with one of the coloring matters and 400 cubic centimeters (13.8 fluidounces) with the other coloring matter, and the remainder with zinc white. For imitating marble with four colors, take 300 cubic centimeters (10.1 fluidounces) of the glue solution to each of the three coloring matters, and mix the rest with 130 grammes (4.58 ozs.) of zinc white.

The proportions by weight of the mixtures for 10 different varieties of imitations of marble and enamel are as follows:—

a. Mix 600 cubic centimeters (20.3 fluidounces) of

the glue solution with 50 grammes (1.76 oz.) of colcothar and 70 grammes (2.46 ozs.) of zinc white, and the rest of the glue solution with 180 grammes (6.34 ozs.) of zinc white.

b. Mix 600 cubic centimeters (20.3 fluidounces) of the glue solution with 50 grammes (1.76 oz.) of colcothar, and the rest of the glue solution with 150 grammes (5.29 ozs.) of zinc white.

c. Mix 400 cubic centimeters (13.8 fluidounces) of the glue solution with 35 grammes (1.23 oz.) of zinc white and 30 grammes (1.05 oz.) of colcothar, 400 cubic centimeters (13.8 fluidounces) of the glue solution with 30 grammes (1.05 oz.) of yellow ochre, and the rest with 150 grammes (5.29 ozs.) of zinc white.

d. Mix 400 cubic centimeters (13.8 fluidounces) of the glue solution with 30 grammes (1.05 oz.) of colcothar, 400 cubic centimeters (13.8 fluidounces) of the glue solution with 25 grammes (0.88 ozs.) of sepia, and the rest with 150 grammes (5.29 ozs.) of zinc white.

e. Compound 600 cubic centimeters (20.3 fluidounces) of the glue solution with 30 grammes (1.05 oz.) of quite concentrated and filtered solution of aniline black and the rest with 180 grammes (6.34 ozs.) of zinc white.

f. Mix 300 cubic centimeters (10.1 oz.) of the glue solution with 25 grammes (0.88 oz.) of colcothar, 302 cubic centimeters (10.1 fluidounces) of the glue solution with 25 grammes (0.88 oz.) of yellow ochre, 300 cubic centimeters (10.1 fluidounces) of the glue solu-

tion with 25 grammes (0.88 oz.) of sepia, and the rest with 130 grammes (4.58 ozs.) of zinc white.

g. Mix 600 cubic centimeters (20.3 fluidounces) of the glue solution with 40 grammes (1.41 oz.) of lamp-black. For gray add sufficient zinc white to produce the desired shade. The rest of the glue solution is mixed with 180 grammes (6.34 ozs.) of zinc white.

h. Mix 300 centimeters (10.1 fluidounces) of the glue solution with 25 grammes (0.88 oz.) of umber, 300 cubic centimeters (10.1 fluidounces) of the glue solution with 25 grammes (0.88 oz.) of bole, 300 cubic centimeters (10.1 fluidounces) of the glue solution with 25 grammes (0.88 oz.) of ochre, and the rest with 130 grammes (4.58 ozs.) of zinc white.

i. For enamels mix 600 cubic centimeters (20.3 fluidounces) of the glue solution with 30 grammes (1.05 oz.) of ultramarine, and the rest with 180 grammes (6.34 ozs.) of zinc white.

k. Mix 600 cubic centimeters (20.3 fluidounces) of the glue solution with 40 grammes (1.41 oz.) of chrome green, and the rest with 180 grammes (6.34 ozs.) of zinc white.

For imitating mother of pearl veneers, 12 grammes (0.42 oz.) of silver bronze, which need not be genuine, are ground with a little glue solution or water and intimately mixed with the above solution of glue. The bronze powder must not be in a dry state when stirred into the glue, as lumps would be formed and the veneers become spotted. In place of bronze, essence of fish scales, which is of course far more costly, can

be used.* The glue solution thus prepared is then compounded with different aniline colors according to the tint desired.

a. For yellowish veneers no coloring matter is required, or the desired shade is obtained by an addition of some solution of picric acid.

b. For colorless veneers or those of slightly reddish tints a smaller or greater number of drops of a concentrated solution of fuchsine are added in order to counteract the yellowish color of the glue solution. For these imitations of mother of pearl veneers, concentrated solution of gelatine compound with 15 per cent. of glycerine can be employed, especially when essence of fish scales is used.

c. For *blue*, the glue solution is compounded with *bleu de Lyons*, care being had not to use too much, as otherwise the imitation becomes indistinct. The proper degree of coloring is tested by allowing a few drops of the colored glue solution to fall upon a glass plate.

* This preparation is also known by the name *Essence d'Orient.* The material for its production is furnished by a small white fish very common in the rivers of continental Europe. It accompanies the scales of this fish, and is detached when the scales are rubbed up for a considerable time and thrown into a vessel of water. To collect the essence the water is poured off from the vessel upon a fine hair sieve which retains the scales and allows the water and the product sought to pass through it. The latter sinks to the bottom and is obtained pure by decanting the water. A little ammonia is added to prevent decomposition.—W. T. B.

d. For *red*, solution of fuchsine or carmine is used, the latter being obtained by dissolving commercial carmine powder in alcohol.

e. Orange colors are produced by an addition of solution of *chrysaniline* generally sold under the name of Victoria orange, and *violet* by adding aniline violet. For these, as well as for the solution colored with fuchsine, the plates must *not* be rubbed with oil, as even the smallest trace of the latter discolors these colors in drying, or at least the veneers will show spots without color.

3. *Pouring the colored solutions of glue upon the plates.*—For imitations of marble and enamel, the glass plates, after rubbing with oil, are placed, rubbed surface up, in a perfectly level position. The proper portion of the white ground-mass, after becoming somewhat thickish, is then poured upon the plates, and the gaps left free in pouring filled in and smoothed with a knife-shaped tool of horn or bone. Upon this white ground the respective colored glue solutions are then poured in a zigzag form, and in conformity with the desired design, drawn through the ground-mass with a glass rod. If several differently colored glue solutions are to be applied, as given, for instance, under 2*f*, they should be poured in quick succession, so that the succeeding color runs into the preceding, or that a white strip or spot remains between each color. The whole is then intermingled by the glass rod, according to the design. If the latter is to have sharply defined lines and spots, the respective colored

solution of glue is used somewhat thicker, but if, on the other hand, the design is to be somewhat blended, the glue solutions are used somewhat warmer, and consequently more thinly fluid. After solidification of the glue solutions the plates are placed in a cool room for two or three hours.

Imitations of malachite are prepared in a similar manner. Four glue solutions of different shades of green from the darkest to the lightest tint are prepared and poured upon a slightly greenish ground, so as to imitate the characteristic curves and veins of malachite, which are then further traced with a comb with teeth standing at unequal distances from each other.

The glass plates set aside to be used for imitation of mother of pearl are now taken in hand. The solutions of glue are kept warm over a water bath and thoroughly stirred every time before pouring them upon the plates. The formation of a film on the surface of the glue solution must be strictly avoided.

For pouring out the solutions it is best to use a porcelain vessel provided with a spout and handle, and having a capacity of about 200 cubic centimeters (6.75 flu. oz.). The portion of glue solution required for each plate (about 50 cubic centimeters (1.7 flu. oz.)) is then measured into one of the porcelain vessels, and, after standing a short time, poured upon the plate and uniformly distributed. The production of a mother of pearl design requires some skill and practice. A comb with teeth set 15 millimeters (0.59

inch) apart is used. It is held in a somewhat oblique position, the teeth are gently pressed upon the glass plate, and, with frequent turnings of the comb at a right angle, cycloidal motions executed. The operation is carried on from the front to the back edge of the glass plate, and when the glue begins to thicken on the edges, continued at the softer places until the desired design is produced, care being had not to touch places which have already acquired a certain degree of solidity, as this would mar the pattern. After treating all the plates in this manner, they are set aside in a cool room for two or three hours.

4. *Transferring the layer of glue to a layer of gelatine.*—For each dozen of veneers soak 70 grammes (2.46 ozs.) of gelatine, and then melt them in a water bath, and after adding glycerine equal to 10 per cent. of the dry gelatine, let the mixture settle.

The glass plates treated with colcothar and Spanish chalk are now placed in a perfectly level position, and after pouring 160 cubic centimeters (5.4 flu. ozs.) of gelatine solution upon each of them, the gaps left in pouring are filled in and smoothed with the glass rod. The front edge of a plate covered with a colored layer of glue is now, glue side down, placed upon the front edge of a gelatine plate, while the back edge of the former is gradually lowered until the glue plate lies firmly upon the gelatine plate.

We would here remark that the gelatine solution must only be allowed to cool off sufficiently to prevent the melting of the glue plate on touching it. If it is

cooler the veneers will have blisters. It must further be looked to that, before placing the first plate upon the gelatine plate, no gelatine escapes, and that any excess only runs off after the back edge of the glue plate touches that of the gelatine plate.

The plates are now allowed to rest quietly until the gelatine is congealed, when they are removed to a cool place where they remain five to six hours.

Imitations of mother of pearl are treated in the same manner with the exception that the gelatine solution is colored with the same coloring matter as the glue solution. For colorless or yellowish veneers the gelatine solution is not colored.

After six hours the first glass plate is detached from the layer of glue by loosening the latter around the edges with a knife blade, and the plate gradually lifted off commencing at one corner. With some care and skill, this operation is readily accomplished without detaching the gelatine layer.

5. *Drying and detaching the veneers.*—The veneers with the gelatine layer still adhering to the glass plate are now dried. This is done in a heated room in which the veneers are arranged upon frames so that they stand almost perpendicular. The hot air for heating the room enters near the ceiling while the moist air is drawn away near the floor. The temperature of the lower zone where the fresh plates are placed should not exceed 20° C. (68° F.). The plates are moved up higher every day until, on the third or fourth day, they have become entirely dry.

Before removing the veneers from the drying-room they should be tested in regard to their dryness. They are sufficiently dry, when, on pressing the finger nail upon the glue, no impression is made.

After removal from the drying-room the plates are allowed to cool off for at least two hours before detaching the veneers. The operation begins by detaching the gelatine layer on the edges with a very thin knife blade. The operator then takes hold of one corner of the veneer and draws it gradually and carefully from the glass plate. After trimming the edges the veneers are ready for use.

If the veneers are required to resist the action of water, mix with the solution of gelatine compounded with glycerine 10 cubic centimeters (0.33 flu. oz.) of a solution of 5 parts of chrome-alum in 100 of water to every plate, and immerse the veneers for a short time after they have been detached from the first plate, in a similar solution of chrome-alum.

Veneers prepared by these methods can be used for various purposes in architecture and in the manufacture of furniture. We have seen Tennessee and other marbles so closely imitated, that when used for table plates, etc., the fact of their being imitations could only be detected by the closest scrutiny. The veneers are also much used for fancy and inlaid work, for coating columns, etc. To prevent their blistering and coming off, it is recommended to add one-quarter of its weight of glycerine to the glue with which they are to be attached to the articles.

Gelatine Foils.

Large quantities of gelatine foils, which are leaves of gelatine about as thick as a sheet of paper, are produced in England and France where their manufacture forms a special branch of industry. They are either simply colored or printed with neat designs in gold or silver.

The fabrication is quite simple. Cover pure gelatine with water, and after swelling up, pour off the water and dissolve the jelly over a water-bath. After allowing the solution to cool somewhat add the coloring matter previously dissolved in water.

In place of pure gelatine, a solution of ordinary bone-glue may be used. In order to clarify it add 4 grammes (0.14 oz.) of oxalic acid dissolved in water to every 2.5 kilogr. (5.5 lbs.) of glue. To make the foils more flexible add also one-half pint of spirit of wine and 8 grammes (0.28 oz.) of rock candy or a small quantity of glycerine.

Aniline colors soluble in water are best adapted for coloring the foils; for *red*, fuchsine, for *blue*, *bleu de Parme*, for *green*, aldehyde green, for *yellow*, picric acid, and for the various shades, mixtures of the above colors.

A durable blue is also produced by indigo solution, yellow, by decoction of saffron, green, by mixing blue and yellow, red by a solution of carmine in spirit of sal ammoniac, and violet, by mixing blue and carmine.

The gelatine solutions are poured upon ground glass

plates, previously polished with elutriated colcothar, and rubbed with Spanish chalk. The foils are so smooth upon the glass side that when dry they can be detached without much difficulty. If both sides are required to be smooth, the foils are dried between two glass plates. In many respects their manufacture resembles that of "Gelatine Veneers."

Gelatine foils are used for printing sacred images, visiting cards, labels, in the manufacture of fancy articles, artificial flowers, etc.

For the manufacture of artificial flowers very soft and flexible sheets are manufactured by adding $\frac{1}{2}$ part of glycerine to 1 part of gelatine and mixing intimately in dissolving the gelatine.

Such gelatine sheets brushed over in addition with Peruvian balsam can also be advantageously used for tying up wounds instead of gutta-percha cloth which tears easily and rots soon. They form an air-tight bandage which clings closely to the parts of the body, and beside the glycerine contained in them exerts a beneficial cooling effect and acts as an antiseptic.

Imitation of Marble.

Boil 560 grammes (1.23 lb.) of good glue into a thick solution, stir into it 280 grammes (9.87 ozs.) of colophony, or still better, Venetian turpentine. Mix finely ground mineral color in a dry state with powdered French chalk to the color of the marble to be imitated and stir enough of it into the above glue solu-

tion to make a stiff paste, and then add a few drops of pure olive oil. Press the mass in stone or gypsum moulds, or roll into thin plates. Cut the plates to the desired patterns, glue them on and allow them to dry. The mass becomes as hard as stone. Any porous places which may be found are filled in with the same composition diluted, and the whole is finally coated with a natural or white polish. By wrapping the composition in a damp linen cloth, it can be kept for a long time. When it is to be used, place it in a pot heated by steam when it will become again plastic. Imitations of marbles of two or more colors are produced by mixing differently colored compositions.

Elastic Glue for Printers' Rollers, etc.

Pour cold water upon good bone-glue and allow it to swell. Then drain off the remaining water and melt the glue over a water bath, evaporating it somewhat until white bubbles arise from the mass. Now add glycerine equal in weight to the quantity of glue used, and after mixing intimately, pour the glue into sheet-iron moulds or upon stone slabs and allow it to solidify. This glue remains permanently elastic, does not spoil, and can be remelted as often as desired.

Molasses can be used instead of glycerine, but the mass is not as durable, and is more liable to spoil by the formation of mould.

Elastic glue for other purposes is obtained by mixing glue and caoutchouc. The compound will resist

the action of water even if it contains but a small percentage of caoutchouc.

Isinglass and its Substitutes.

Isinglass is a glue manufactured almost exclusively in *Russia*, and is made chiefly of the air-bladder, or sound, as it is sometimes termed, of different kinds of fishes, especially of the sturgeon (*Accipenter Huso*). It is the finest and best of animal glues. The best quality is shaped like a lyre, another quality is in square pieces like the leaves of a book; the lowest quality is of all sorts of shapes from its having been dried without care. Isinglass is used for culinary purposes, fining beer and other liquids, for making court-plaster and stiffening silk. A good quality of isinglass should be pure white, semi-transparent, dry and horny in texture, and free from smell. It should dissolve in water heated to 35° to 50° C. (95° to 122° F.) without any residue, and in cooling should produce an almost colorless jelly. When a thin piece of isinglass is looked through by holding it before the eye and daylight, a sort of shining appearance may be observed. Isinglass is often imitated with the intestinal membranes of the calf and of the sheep. This spurious article may be recognized because it does not exhibit the shining appearance before alluded to when held before the light, and because, although inodorous, it has a saltish flavor, and is generally in thinner pieces than the genuine article. If it be torn asunder, it

will be observed that it may be rent in all directions, while genuine isinglass cannot be divided otherwise than in the direction of its fibres. If a piece of artificial isinglass be macerated in water it swells, but instead of retaining its shape, as is the case with the genuine article, it becomes divided into several pieces, forming a sort of curdy precipitate; and if treated with boiling water, about one-third of its weight is left in an insoluble state, and the liquor does not form a good jelly. Isinglass is frequently adulterated with gelatine which is inserted between the leaves and rolled up with it. The best indication of this adulteration is the amount of ash; isinglass yields only 0.9 per cent., while gelatine yields 4 per cent., and adulterated isinglass 1.5 per cent. or more.

Though extensive use is made of isinglass for the purposes stated above, bone-gelatine can in many cases be substituted for it, this being the reason why the importation of isinglass is steadily decreasing and that of gelatine increasing.

Commercial varieties of isinglass are distinguished by their shape, though this is by no means a criterion of quality, as any desired form can of course be imparted to the article.

1. *Leaf Isinglass.*—It consists of leaves 0.1 to 0.15 meter (0.32 to 0.49 foot) long rolled together longitudinally, then bent in the shape of a lyre or horseshoe and dried.

2. *Book Isinglass.*—Flat, square pieces a few inches wide.

3. *Tongue Isinglass.*—Irregular pieces 0.12 to 0.20 meter (4.72 to 7.87 inches) long, 0.2 to 0.8 meter (7.87 to 31.49 inches) wide in the centre, but running to narrow points on both ends.

4. *Ribbon Isinglass.*—Irregular pieces with ragged edges. They are frequently 1.80 to 2.40 meters (5.905 to 7.87 feet) long, but irregular in width.

5. *Thread Isinglass.* — Thin thread-like pieces twisted into various shapes.

I. *Russian Isinglass.*—Russia produces the best and most isinglass. It is principally obtained from fishes belonging to the sturgeon family. The *Acipenser Gueldenstaedtii*, *Br.*, yields the finest, best, and whitest isinglass. It is known by the name of *Patriarch*, and consists of small horseshoe-shaped pieces rolled tightly together. It is very scarce and expensive.

Long staple isinglass of fine quality is produced in the Oural. It is imported in loose leaves, and at times it is twisted like ropes, this kind being preferred, as it is inferior in quality only to Patriarch.

Siberian purse isinglass is of moderately good quality and is in general demand. A small kind of strings in a necklace form is sometimes imported.

A very good sort of Russian isinglass comes into commerce in leaves and books, and is known by the name of *Samovey* leaf. It is obtained, according to the statements of Russian merchants, from the common sheath-fish (*Siluris Glanis*). The pieces are as large as a hand, of the thickness of pasteboard, very solid,

not very flexible and of a white-yellowish color. It is inferior in quality to Astrakhan isinglass, which is one of the best kinds.

In *Russia* the isinglass is generally prepared by boys under the supervision of elder experts. The swimming bladder is first placed in water and left there for some days with frequent changes of the water and removal of all fatty and bloody particles. The warmer the water the more rapidly the operation is completed. The bladders are finally removed and cut longitudinally into sheets which are exposed to the sun and air, being laid out to dry, with the outer face turned down, upon boards of linden or bass wood. The inner face is pure isinglass, which, when well dried, can with care be removed from the external lamellæ. The finer sheets thus obtained are placed between cloths to protect them from the flies, and are then subjected to a heavy pressure so as to flatten them out and render them uniform. After this they are assorted and tied up in packages. The packages composed of the isinglass of the large sturgeon usually contain from ten to fifteen sheets and weigh a pound and a quarter; those of the other contain twenty-five sheets weighing a pound. Eighty of these packages are usually sewed up in a cloth bag, or sometimes inclosed in sheet lead.

The outer lamellæ of the air-bladder, after the isinglass has been removed, also contain a considerable quantity of glue which, when softened in water, is

scraped off with a knife and moulded into little tablets of about the size of a silver dollar, and then dried.

II. *North American or New York Isinglass.*—It is in thin strips several feet long but $\frac{1}{2}$ to $1\frac{1}{2}$ inch wide. It is less soluble than Russian isinglass, and yields frequently a dark-colored solution. It is prepared, according to Dr. J. V. C. Smith's statements, from the air-bladder of the common hake (*Gadus merluccius*), which is macerated in water for a short time, cut open and subjected to pressure between iron rollers, by which it is elongated to the extent of half a yard or more. It is then carefully dried, packed and sent to market. The air-bladder of the common cod (*Gadus morrhua*) is prepared in a similar manner, but yields a poorer kind of isinglass.

III. *East India Isinglass.*—It would seem that for a long time this has been exported from *Calcutta* to *China*, but has only lately attracted the attention of European dealers. It is prepared from the air-bladder of the *Polynemus plebejus*, and comes into commerce either in the form of leaves or purses which seem to consist of the unopened air-bladder. East Indian isinglass has a disagreeable fish odor, due very likely to careless preparation, which makes its use impossible for many purposes and of course depreciates its commercial value. The oval-oblong purses are about nine inches long, three and a half inches wide, weigh about 7 ozs. and have a dark-yellow color. East India leaf isinglass, *i. e.*, the opened and dried air-bladder, consists of yellowish-colored leaves eight to nine inches

long, six to seven inches wide, and about three-tenths of an inch thick. The leaves are sometimes rolled out into long ribbons about one-tenth of an inch thick, the surface of which is covered in places with a thin film of lime.

What is known as picked East India isinglass is brought into commerce in small shreds about two to three inches long, and tapering at the extremities.

A variety of isinglass very white and pure and not inferior in quality to Samovey leaf, has been recently imported from *Manilla*. The fish which yields it is caught in the rivers of *Manilla* and on the coast of the *Philippine Islands*.

IV. *Hudson Bay Isinglass*.—It is brought into commerce in the purse form. Some specimens measure twelve inches in length and three and a half inches in diameter, and weigh one and a half ounces. It is of light-yellow color, nearly transparent, without odor or taste. The inner lining of the sac, which can be readily stripped off, is insoluble in water, while the remaining portion dissolves to a slightly colored jelly. We have been unable to ascertain from what species of fish this isinglass is procured.

V. *Brazilian Isinglass*.—This is imported from *Para* and *Maranham*, and is also called *Cayenne* isinglass. For a long time there existed a doubt from what species of fish this isinglass was procured, but it is now settled that it is prepared from the air-bladder of *Silurus Parkerii*, a fish which is frequently found

in the muddy waters of the rivers in the province Grao Para, where these waters mingle with the sea.

Brazilian isinglass comes in the form of pipe, lump, and honeycomb. On account of its dark color it is not in much demand for ordinary use, but is frequently employed in England for clarifying glue. When digested in water it leaves much insoluble substance behind, being in this respect also inferior to Russian isinglass.

V. *German Isinglass.*—Under this name we may mention the mucous membrane of the sturgeon (*Acipenser sturio*), prepared in Hamburg. When boiled with water it leaves 16 per cent. of insoluble substance.

It is said that an excellent isinglass can be made from the scales of shad and herring, which are first freed from their silvery coating. This may furnish a useful hint to persons who are near some of the great fishery establishments of the country, at *Gloucester, N. J.*, and *Alexandria, Va.*, for instance, where thousands of shad are scaled and salted every year.

To give inferior qualities of isinglass a better appearance and make them more salable, they are frequently bleached with sulphurous acid.

Rohart has introduced a substitute for isinglass under the name of *Ichthyocolle française.* The material used for its manufacture is blood fibrin, which, after washing in running water, is thoroughly kneaded and, after draining, digested at 15° C. (59° F.) with dilute sulphuric acid of 8° to 10° B. for eight days,

after which the mass is freed from acid by washing in running water.

The fibrine freed from acid becomes transparent and gelatinous by treating with weak soda-lye of 3° to 4° B. at 15° C. (59° F.), whereby it swells up and increases hourly in volume. After twenty-four hours it is taken from the soda-lye, and after removing the free soda by washing, heated to 100° C. (212° F.) in a water-bath. The fibrine dissolves and becomes so thinly fluid that it can be filtered. 75 to 80 per cent. of the water is then evaporated, and the fibrine thus prepared can be used as a substitute for isinglass for fining purposes. Ichthyocolla swells quicker in cold water than isinglass; 15 to 20 per cent. divided in water forms a thickly fluid substance which on heating dissolves to a perfectly clear fluid. For fining beer with ichthyocolla add 2 to 10 per cent. of pure tannin, which does not injure its power of dissolving.

Substitute for Animal Isinglass.

Under the name of "*Chinese Isinglass*" an article has recently been introduced which is much liked and threatens to become a dangerous rival of isinglass. It takes especially the place of the latter for culinary purposes and promises to become a very important article of commerce. It is identical with the *Japanese Agar-Agar*, and is obtained by cleansing and boiling certain species of algæ (*Plocaria tenax* and others)

found in *Chinese* and *Japanese* waters. The gelatine possesses the following properties:—

Placed in cold water it softens without dissolving like gelatine, and forms a structureless tubular mass which is not sticky. By boiling, it dissolves more readily than isinglass, but with greater difficulty than gelatine. A 1 to 2 per cent. solution is easily filtered through paper or linen, and when cold forms a solid jelly clear as water and without taste or odor. Jelly prepared with one-half per cent. of Chinese gelatine is more solid than one prepared with 4 per cent. of French white gelatine, retains its consistency longer, and will stand a temperature of 30° to 50° C. (86° to 122° F.) before becoming liquid. Used for jellies, or mixed with other foods, it does not impart to them a glue taste never wanting in bone-gelatine. When decomposed by long standing, it does not acquire a disagreeable odor, while decomposed isinglass or gelatine exhales a putrid smell.

Agar-Agar contains, according to analyses: Cellulose, starch, gum, dextrine, vegetable mucus, vegetable wax, resin, chlorophyll, albumen, a peculiar acid, and several mineral substances.

Artificial Isinglass.

An article, which is claimed to be as good as the genuine product, is prepared from the larger bones of whales, cachelots (sperm whale), dolphins, and other large marine animals. The bones are sawed in suit-

able pieces, and, after boiling in water for some time to free them from fat, treated with hydrochloric acid to remove the calcareous earth. They are then washed with water to remove all traces of the acid, dried, and again boiled for a considerable time, and finally clarified with chalk or milk of lime. The soup gelatinizes on cooling and is cut into cakes and dried upon nets.

VIII.

CEMENTS AND PASTES.

In speaking of cements and pastes, attention will principally be given to those employed by the jeweller, manufacturer of china, shoemaker, bookbinder, and other persons in their respective callings. The term cement is usually applied to such bodies as are capable of uniting, by their interposition, homogeneous and heterogeneous substances. This object will be the better accomplished the greater the force required to separate two cemented bodies.

Cements and pastes are extensively used. It frequently becomes necessary to cement together the most heterogeneous substances, such as metal and glass, leather and metal, rubber and tissues, etc.

The great variety of substances entering into the manufacture of cements and pastes makes a division of them extremely difficult. Strohmann divides them into the following groups:—

1. *Oil cements.*
2. *Resinous cements.*
3. *Cements containing rubber or gutta percha.*
4. *Cements containing glue, or starch paste.*
5. *Lime cements.*

Generally speaking, this division is correct; the only change we would suggest is to apply the term *agglutinant* or *paste* to bodies containing glue and starch paste.

When we attempt a division of the cements according to the bodies to be cemented, we find that the result will be a larger number of groups; as we must take into consideration whether the articles to be cemented have to be heated or not, whether they are to come in contact with water or other liquids, and other circumstances which would necessitate modifications in the composition of the cements themselves.

According to this, we might group the cements as follows:—

1. *Cements for glass and porcelain, for repairing broken articles, for fastening glass letters upon show-windows, etc.*
2. *Cements for metals not exposed to an increase of temperature, for instance, for tightening the joints of gas and water pipes.*
3. *Cements for stoves and other articles, which have to stand an increased temperature.*
4. *Cements for chemical apparatus, i. e., such as will have to resist the action of chemical agents.*

5. *Cements to protect vessels of glass, porcelain, or metal against the action of fire.*
6. *Cements for filling hollow teeth, for microscopical preparations, and other delicate articles.*
7. *Cements for special purposes, for instance, for cementing meerschaum, tortoise shell, etc.*

Chemical Nature of Cements.

The different varieties of cement frequently contain substances which act chemically either upon each other, or upon the bodies to be united with them. To determine the practical availability of a variety of cement for a determined purpose, it is of importance to know the reciprocal behavior of these substances towards each other, as from this we are able to judge at once whether a cement is suitable for a certain purpose or not.

Oil Cements.

The fluid fats, ordinarily called oils (though there are oils which remain solid at an ordinary temperature, as, for instance, palm oil and cocoanut oil), can, as regards their behavior on exposure to the air, be divided into two large groups: drying and non-drying oils. As samples of these groups we give two well-known oils: olive oil and linseed oil.

If a thin layer of olive oil protected from dust is

exposed to the air, it will remain fluid for years and retain its characteristic oily consistency. The only change it undergoes is that it becomes somewhat more thickly fluid and rancid, and acquires a darker color; but it never dries up.

Linseed oil treated in the same manner solidifies in the course of a few weeks to a hard, tough, and elastic mass, resembling, as regards its physical qualities, resin or caoutchouc.

By compounding a drying oil with a small quantity of litharge, pyrolusite, manganous borate, etc., and heating the mixture to the boiling point, it acquires the property of drying in a few hours when exposed to the air in a thin layer. Oil so treated has been changed to a varnish.

By bringing a drying oil in contact with a body possessing strong basic properties a peculiar process takes place; the sebacic acids contained in the oil combine with the basic bodies to solid combinations which are insoluble in water, and, on exposure to the air, change gradually into masses as hard as stone. Such combinations, as regards their chemical composition, resemble ordinary soap, and for this reason are called insoluble soaps to distinguish them from ordinary soap which is soluble in water.

Burned lime, calcined magnesia, whiting, ferric oxide, litharge, and minium possess the capacity for forming insoluble soaps on coming in contact with drying oils and, still more quickly, with varnishes pre-

pared from them. The hardness of these soaps in time increases considerably by the oil not saponified drying in. The oil cements are principally used for tightening water and gas pipes, as they resist the action of water, steam, and gas.

The only evil connected with these cements is that they must reach a certain age before becoming entirely hard, and that, on account of the high price of drying oil or varnish which is absolutely required for their preparation, they are rather expensive. The ordinary glazier's putty and the minium and linseed oil cement used in constructing water and gas conduits belong to this group.

Resinous Cements.

By resins we understand a number of natural constituents of plants which exude in thick viscous masses through incisions made in the trees, and on exposure to the air are gradually converted into less transparent, brittle masses. When heated they melt more or less easily into a thick, ropy liquid, and brought in contact with an ignited body they burn with a bright flame and the diffusion of much fuliginous smoke.

By making incisions in the bark of any of the whole genus of *Pinus* belonging to the *Coniferæ* family, a viscous mass of a strong odor, called turpentine, is obtained. It consists of a solution of common rosin in the essential oil of turpentine, and when distilled yields from 75 to 90 per cent. of colophony or rosin, which

remains in the retort, and from 25 to 10 per cent. of the essential oil, commonly called spirits of turpentine. Pure rosin is a brittle, tasteless, and almost inodorous mass of a light yellow color and a smooth shining fracture.

The various resins found in commerce, such as shellac, mastic, elemi, copal, etc., are formed in a similar manner.

The principal points of importance for our purpose are the different degrees of hardness and brittleness and the melting points of the various resins. While some possess but slight hardness, for instance elemi, others, such as copal and amber, excel in this respect and their brittleness and high melting point.

To decrease the brittleness of resins, essential oils are sometimes added, or resinous cements are mixed with oil cements or a fat drying oil, or compounded with caoutchouc cement.

Resinous cements are either softened by heating or entirely melted, or solutions of resins in volatile solvents are used, which, in evaporating, leave the resin behind.

The resinous cements possess great power of resistance, and are therefore well adapted for tightening water and gas pipes, but they have the disadvantage of not standing a high temperature and possessing a certain degree of brittleness which renders them unfit for the cementing of articles exposed to frequent shocks.

Many of these cements, especially those prepared with pitch or asphaltum, can be produced at a very

low cost, and do excellent service for water-proofing vessels, water-reservoirs, brickwork, etc.

Caoutchouc and Gutta-Percha Cements.

Caoutchouc, gum elastic, or India rubber is derived from the milky juices of certain tropical plants. It is distinguished by a high degree of elasticity and indifference to the action of chemical agents.

Both these properties make it a valuable material for cement, and it is much used for this purpose either in the form of solution or as a constituent of other compositions. For cements which are to have a certain degree of elasticity combined with indifference toward chemical agents, it is absolutely indispensable, as no other known body possesses these properties in such a high degree.

The derivation of gutta percha is similar to that of caoutchouc. At an ordinary temperature it forms solid and very tenacious masses, of a leather-like consistency, but at a somewhat higher temperature (below the boiling point of water) it is converted into a very plastic, soft mass, which can be drawn into very fine threads, and rolled to very thin plates.

By itself or mixed with other substances it furnishes an excellent cement, possessing the valuable properties of tenacity and pliancy when exposed to shocks. As regards resistance to the action of water and chemical agents it is almost equal to caoutchouc, and, being

cheaper, is frequently used as a substitute for the latter.

Glue and Starch Cements.

By itself, *i. e.*, converted by boiling with water into a thickly fluid mass, which solidifies on cooling, glue cannot be classed with the cements, but belongs to the agglutinants; the same holds good as regards paste, *i. e.*, starch or flour swelled and boiled in water.

But compounded with other substances both yield excellent cements, in which a part of the properties distinguishing glue solution and paste is preserved. They both possess the property of decreasing the brittleness of many cements, but unfortunately the latter thereby lose their power of resisting the action of water, as starch as well as glue swells in water, and the latter, when moist, passes quickly into putrefaction and destroys the cement.

In a wider sense isinglass, compounds of glue and vinegar, of lime and glue, etc., must be classed with the glue cements, and ordinary flour and shoemakers' paste with starch cements.

Lime Cements.

Lime possesses the property of forming insoluble combinations with egg albumen or caseine; this being the reason why lime cements, of which there are a great number, are generally composed of burned lime and

one or the other of the above substances. Lime compounded with a solution of water-glass forms also very solid and durable cements.

Although the cements and agglutinants mentioned in the foregoing are most frequently used, a compound of different cements is often employed, in consequence of which the composition of many cements is very complicated.

In the following we give a description of the preparation of the different kinds of cement, according to the manner of their employment.

I.

Oil Cements.

Oil cements, as already explained, must be considered as a variety of soaps insoluble in water, formed by the action of drying oils or varnish upon various basic combinations.

The most important of this class is the cement used for securing window panes. Good glaziers' putty is a product of extraordinary durability, and, besides for puttying glass and wood, can also be used for joining many other bodies.

Glaziers' Putty.

This is easiest prepared by gradually mixing fine whiting with linseed oil; which is best effected by

placing the linseed oil in a vessel of sufficient capacity to hold the entire quantity of putty to be prepared and adding gradually the whiting, stirring constantly until as thick a mass as possible is formed. When it can no longer be stirred it is rolled in chalk dust and kneaded with the hands until it has assumed the consistency of butter, *i. e.*, has become so plastic that it can be brought into any desired shape by the exertion of a gentle pressure.

As the work of kneading large masses with the hands or feet must be continued for a long time in order to obtain an entirely uniform product, and is consequently very laborious, it is recommended to use the following contrivance.

Two wooden rollers rest in a suitable frame and can be brought together or removed from each other by means of two screws. When the mixture of whiting and linseed oil is of sufficient consistency to allow kneading, it is fashioned into a cylinder and rolled out between the above rollers to a long thin band, which is caught in a vessel. The band is balled together, the ball reformed into a cylinder, and the latter again passed through the rollers, the operation of balling and rolling being continued until a uniform mass is obtained.

The finished putty should be used as soon as possible. In order to keep it any length of time great precaution should be used, as it dries very quickly and becomes brittle when exposed to the air. The best means of preserving it is to wrap it in oil-paper and keep it in a damp cellar. A very simple way of keeping the

air from putty is to place it in a vessel filled with water. In this manner it can be preserved fresh for several weeks, but if kept longer it becomes friable, and can only be restored by thoroughly working it in the same manner as fresh putty.

Instead of linseed oil, linseed oil varnish can be used for preparing glaziers' putty, especially when a very quickly drying article is demanded.

To detach old putty adhering so firmly to glass that it cannot be removed by mechanical means, apply a mixture of one part of burned lime, two of soda and two of water, which will soften it in a short time so that it can be removed without difficulty.

Litharge Oil Cement.

Like the lime contained in glaziers' putty, litharge also possesses the property of forming insoluble combinations, *i. e.*, lead soaps, with linseed oil. By mixing finely ground litharge with linseed oil a yellow cement is obtained which gradually solidifies to a mass as hard as stone.

Minium Oil Cement.

Minium or red lead furnishes a cement of the same beautiful red color as the oxide itself, which is preferably used for joining water and gas pipes. To allow of its ready application it is made of less consistency than glaziers' putty.

Lead preparations furnish excellent cements, but have the disadvantage of great weight and a high price. For many purposes a part of the lead combination can be suitably replaced by a substance of less weight, such as whiting, or, still better, burned lime slacked with sufficient water to convert it into a powder.

The quantity of the substitute added varies very much, there being, for instance, many varieties of so-called minium oil cement, which contain only about 10 per cent. of minium.

Zinc Oil Cement.

Zinc oxide, known in commerce under the name of zinc white or zinc gray, mixed with linseed oil or linseed oil varnish, gives an excellent white or gray cement.

The mode of preparing lead or zinc oil cements is nearly the same as that of making glaziers' putty, but as they are not made of sufficient consistency to allow of kneading like glaziers' putty, the mixture, in case large quantities are to be prepared at one time, is ground, like oil paints, in an ordinary color-mill.

Instead of linseed oil varnish thick lacquer, such as copal or amber lacquer, may be used for preparing cements with lime, zinc oxide, or litharge. Such cements solidify to very hard masses of a beautiful lustre and do not become full of cracks and fissures. Though the high price of the lacquers will prevent the general use of these cements, they are well adapted

for cementing many articles, for instance, wood on glass, glass on metal, etc.

Lead and zinc cements are best preserved in tin cans with well-fitting lids. To exclude the air, paste a strip of paper over the joint of the box and the lid. Kept in this manner, the cements will retain their proper consistency for years and even improve in homogeneousness.

Mastic Cement, Mastic or Pierres de Mastic.

Under this name masses are brought into commerce which are well adapted for moulding ornaments such as figures, columns, etc., to be exposed to the weather. They are comparatively cheap, and it is rather remarkable that they are not more generally known and used for technical purposes.

To prepare large quantities of this cement suitable mills and mixing vessels are required, as the conversion of the materials into a dust-like flour is an indispensable condition of the success of the work. The materials most generally used are fine quartz sand, finely ground calcareous sand, and varying quantities of litharge or zinc oxides, besides as small a quantity of linseed oil as possible.

The linseed oil combines with the litharge or zinc oxide to an insoluble soap, which incloses the other material and forms a mass acquiring the hardness of sandstone in thirty to fifty hours.

After converting the materials into a fine powder, the mixing is accomplished in barrels filled about three-

quarters full and revolved by water-power. When a thorough mixture has been effected the pulverulent mass is placed in sheet-iron vessels and saturated with linseed oil, and then moulded at once, as it solidifies in one or two days.

French Mastic.

	Parts.
Quartzsand	300
Pulverized limestone	100
Litharge	50
Linseed oil	35

Paget's Mastic.

	Parts.
Sand	315
Whiting	105
White lead	25
Calcined minium	10
Solution of sugar of lead	45
Linseed oil	35

Various colors can be imparted to the mastic by adding, for instance, for red, colcothar, for gray, pulverized charcoal, for blue, smalt, for brown, pyrolusite, etc.

Cement for Wash-basins.

	Parts.
Glass meal	40
Elutriated litharge	40
Linseed oil varnish	20

The glass meal is obtained by heating glass, throwing it into cold water, and grinding and elutriating. After moistening the fine powders with the linseed oil, heat the mass in a boiler, stirring constantly, and adding some linseed oil, if a more thinly fluid mass is desired. Press the cement while hot in the joints to be cemented. It solidifies in two or three days, when the vessel can at once be used.

Water-proof Linseed-Oil Cement.

No. 1.

		Parts.
A.	Caoutchouc	7
	Oil of turpentine	140
	Linseed oil	40
B.	Turpentine	100
	Sulphuric acid	3
	Zinc white	10

To prepare solution *A*, place the caoutchouc in the oil of turpentine in a bottle. It swells very much without actually dissolving. After adding the linseed oil, reduce the entire mass by boiling to one-half the volume originally occupied by it.

Solution *B*, is prepared by stirring the sulphuric acid into the turpentine and allowing it to stand for twelve hours. To remove the sulphuric acid, the thick mass which has been formed is then kneaded in water in which the zinc oxide has been distributed. After

drying, the resulting mass is dissolved in the warm fluid *A*.

Water-proof Linseed-Oil Cement.

No. 2.

	Parts.
Linseed oil	8
Litharge	12
Burned lime	88

Boil the linseed oil and litharge half an hour, then stir the lime into the hot mass, and use the mixture hot. This cement is excellent for filling in joints between stones, for flat roofs, water reservoirs, etc. For a better adhesion of the cement, apply a coat of linseed oil varnish to the surfaces to be cemented. Porous stones are made waterproof by heating the cement in a boiler and adding sufficient linseed oil to form a mass which can be readily worked with a smoothing board. Apply as hot as possible.

Serbat's Linseed-Oil Mastic.

	Parts.
Pyrolusite	60
Sulphate of lead	60
Linseed oil	10

After thoroughly drying the materials mix the sulphate of lead with the linseed oil, then add twenty parts of the pyrolusite, and, after mixing and working

it thoroughly, add gradually the rest of the pyrolusite in small portions and with constant kneading.

Stephenson's Oil Cement.

	Parts.
Litharge	100
Lime slacked to a powder . .	50
Sand	50
Linseed oil varnish	15

Alum Oil Cement.

Dissolve good hard soap, by heating in rain water, dilute the thickly fluid mass and add saturated alum solution as long as a precipitate is formed. Collect the gelatinous precipitate of alumina soap thus formed upon a cloth, and, after draining, pour rain water over it ten to twelve times to remove the salts as much as possible. After washing, dry the alumina soap, and rub it to a fine powder.

To prepare cement rub a portion of the powder with sufficient linseed oil varnish to form a plastic dough, which is used for filling in the joints.

This cement is water-proof, resists high temperatures without being absolutely fire-proof, and, on account of its light color, is well adapted for joining marble plates, etc.

Oil Cement for Glass.

	Parts.
Litharge	30
Burned lime	20
White pipe clay	10
Linseed-oil varnish	6

Oil Cement free from Lead for Steam Pipes.

	Parts.
Graphite	12
Heavy spar	16
Slacked lime	6
Boiled linseed oil	6

Oil Cement for Steam Pipes.

No. 1.

	Parts.
Litharge	25
Air-slacked lime	10
Quartz sand	10

Mix the ingredients quickly with hot linseed oil and work the mass thoroughly in a hot mortar. After coating the defective places in the pipes with linseed-oil varnish apply the cement hot, and after partial solidification make it still tighter by beating.

Oil Cement for Steam Pipes.

No. 2.

Boil 60 parts of graphite, 50 of air-slacked lime, 60 of elutriated heavy spar in 35 of linseed oil, stirring constantly. Apply the mixture hot.

Oil Cement for Marble.

	Parts.
Elutriated litharge	10
Brickdust	100
Linseed-oil varnish	20

Prepare in the same manner as glaziers' putty. For various colors add zinc white for white, minium for red, pyrolusite for brown, etc. Previous to applying the cement saturate the surfaces of the stones to be cemented with linseed-oil varnish.

Linseed-Oil Cement for attaching Metal Letters to Glass.

Heat 9 parts of mastic, 18 of litharge, 9 of white lead, and 27 of linseed-oil. Apply the mixture hot.

Linseed-Oil Cement for Metal.

Rub together boiled linseed oil with lime slacked to a powder upon a stone. Apply a very thin layer to the metal parts to be cemented and join them by strong pressure.

Oil Cement for Porcelain.

Stir 20 parts of white lead and 12 of white pipe clay into 10 of boiling linseed oil previously boiled and knead the mass thoroughly. After cementing let the articles stand quietly for several weeks.

Diamond Cement.

	Parts.
Litharge	30
Air-slacked lime	10
Whiting	20
Graphite	100
Linseed oil	40

This excellent cement for metal must be applied hot.

Hager's Diamond Cement.

	Parts.
Whiting	16
Elutriated graphite	50
Litharge	16

Mix the pulverized ingredients with sufficient old thick linseed-oil varnish to form a plastic dough.

II.

Resinous Cements.

Resinous Cement for Amber is obtained by melting mastic in linseed oil. Volatile copal lacquer can also be advantageously used for the purpose.

Resinous Cement for Turners.

	Parts.
Colophony	10
Wax	10
Yellow ochre	10

Resinous Cement for Ivory and Bone.

Melt at a moderate heat equal parts of white wax, colophony, and oil of turpentine to form a thickly-fluid mass. For coloring the cement add elutriated minium, ultramarine, etc.

Resinous Cement for White Enamelled Clock Faces.

	Parts.
Dammar	100
Copal	100
Venetian turpentine	110
Zinc white	60
Ultramarine	3

Apply the cement hot and polish when solidified.

Resinous Cement for Glass.

No. 1.

Melt carefully 60 parts of bleached shellac and 10 of turpentine. If too thick, dilute the mass with some oil of turpentine.

Resinous Cement for Glass.

No. 2.

20 parts of shellac, 5 of elemi, 10 of turpentine. Prepare as above.

Resinous Cement for Glass upon Glass.

10 parts of shellac, 2 of turpentine, and 10 of pulverized pumice stone.

Resinous Cement for Glass upon Metal.

Melt together 40 parts of colophony, 20 of colcothar, 10 of wax, and 10 of turpentine. Apply hot to the heated surfaces to be cemented.

Resinous Cement for Metal Letters upon Glass.

35 parts of pine rosin, 7 of colophony, 4 of turpentine, and 5 of plaster of Paris.

Resinous Cement for Wood.

100 parts of shellac and 45 of strong spirit of wine. This cement serves for joining wood, which, on account of exposure to water, cannot be glued. Apply the cement to the surface of one of the pieces, and after placing upon it a piece of tissue paper press upon it the other piece of wood previously coated with the cement.

Resinous Cements for Knife Handles.

Melt together 20 parts of colophony, 5 of sulphur, and 8 of iron filings.

Pour some of the hot mixture into the handle, and then push in the knife previously heated.

Resinous Cement for Petroleum Lamps.

Boil 12 parts of colophony in 16 of strong lye until it is entirely dissolved and on cooling forms a tenacious solid mass. Dilute this with 20 parts of water, and carefully work into it 20 parts of plaster of Paris. This cement is insoluble in petroleum, and is especially adapted for cementing the glass parts of lamps to the metal. It is also a good material for stoppers for petroleum bottles.

Resinous Cement for Porcelain.

	Parts.
White-pine rosin	14
Elemi	7
Shellac	7
Mastic	7
Sulphur	42
Brickdust	20

Resinous Cement for Porcelain which is to be heated.

Heat carefully 10 parts of amber in a large spoon, stirring constantly, until it evolves heavy vapors of a strong odor. Rub the melted mass as finely as pos-

sible, and after placing the powder in a bottle, pour over it a mixture of bisulphide of carbon and benzine. Close the bottle air-tight to prevent the evaporation of the very volatile solvent. When the powder is dissolved remove the cork and replace it by one provided with a small brush. The application of the cement and pressing together of the parts to be cemented must be effected as quickly as possible. In articles properly cemented the joint can only be detected by the closest examination. This cement holds so well that cups and saucers, soup-tureens, etc., mended with it can be used for years.

Shellac and Petroleum Cement.

Dissolve 26 parts of shellac and 5 of turpentine in 15 of petroleum.

This cement has the advantage over ordinary shellac cement, which is generally very brittle, of possessing a certain degree of elasticity. The solution can be kept for any length of time in well-stoppered bottles.

Resinous Cement for Horn, Whalebone, and Tortoise Shell.

Dissolve 10 parts of mastic and 4 of turpentine in 12 of linseed oil. Apply hot.

Best Cement for Tortoise Shell.

Dissolve 30 parts of mastic, 90 of shellac, and 6 of turpentine in 350 of spirit of wine of 90 per cent.

Cement for Terra Cotta Articles.

Melt together 70 parts of rosin, 70 of wax, and 16 of sulphur, and stir into the mass 8 parts of hammer slag and 8 of quartz sand. Coat the fractured surfaces with oil of turpentine, apply the cement as quickly as possible, and press the surfaces together. It is advisable to heat the terra cotta previously to 70° or 80° C. (158° or 176° F.) After cementing the article smooth the joint with a heated knife and dust very fine terra-cotta powder through a linen bag upon the soft cement in order to give it exactly the same color as the article itself.

Mastic Cement for Glass.

	Parts.
Mastic	15
Bleached shellac	10
Turpentine	5

This mass sufficiently diluted with hot oil of turpentine furnishes an excellent cement for fractured glass and gems. Being colorless, the joint can scarcely be detected, provided the cementing has been skilfully done.

To attach gems to glass of the same color, the cement is colored with aniline colors dissolved in spirit of wine, care being had to give it the same shade as the gem and the glass.

Stick Mastic Cement.

Melt together, at as low a temperature as possible, 10 parts of mastic and one of turpentine, and pour the mass into suitable moulds.

For use, heat the fractured surfaces of the article strongly so that the cement on being rubbed over them melts, then press the surfaces together and continue the pressure until the cement solidifies.

Sulphur Porcelain Cement.

	Parts.
White pitch	18
Sulphur	28
Bleached shellac	4
Mastic	8
Elemi	8
Glass meal	28

Insoluble Resinous Cement for Wooden Vessels.

Melt together 60 parts of colophony, 20 of asphaltum, and 40 of brickdust, and pour it hot into the joints. This cement resists the action of lye, caustic lime, sulphuric and hydrochloric acids.

Cement for Bottle Corks.

An excellent material for sealing wine-bottles consists of 2 parts of wax, 4 of colophony, and 2 of pitch.

III.

Caoutchouc Cements.

Caoutchouc Cement for Glass.

No. 1.

	Parts.
Caoutchouc	1
Mastic	12
Dammar	4
Chloroform	50
Benzine	10

Caoutchouc Cement for Glass.

No. 2.

	Parts.
Caoutchouc	12
Chloroform	500
Mastic	120

This cement, when applied to glass, adheres immediately, and possesses a high degree of elasticity. It can be advantageously used for joining together the glass panes of hothouses.

Caoutchouc Cement for Glass.

No. 3.

Dissolve, without application of heat, 2 parts of caoutchouc and 6 of mastic in 100 of chloroform. The cement, which is entirely transparent, must be

applied as quickly as possible, as it solidifies in a very short time.

Soft Caoutchouc Lime Cement.

Melt 10 parts of tallow in a brass pan and gradually add 150 parts of caoutchouc in small pieces, and stir constantly until all the caoutchouc is dissolved. Keep in readiness a well-fitting lid to be able to extinguish the flame immediately in case the caoutchouc catches fire. When all is melted stir in 10 parts of slacked lime.

This cement is especially adapted for sealing bottles containing caustic substances, such as nitric acid, etc. It remains always tenacious, being therefore suitable for cementing bodies exposed to repeated shocks.

Hard Caoutchouc Cement.

	Parts.
Caoutchouc	150
Tallow	10
Minium	10

This cement is prepared in the same manner as the above. The addition of minium imparts to it a red color, and solidifies it in a short time to a mass as hard as stone.

Marine Glue.

This cement, which is only a glue in name, is waterproof, and can be used to cement metal, wood, glass, stone, pasteboard, etc., and is especially adapted for caulking vessels.

Suspend 10 parts of caoutchouc inclosed in a bag in a vessel containing 120 parts of refined petroleum, so that only half of the bag is immersed, and allow it to remain ten to fourteen days in a warm place. Then melt 20 parts of asphaltum in an iron boiler, and add the caoutchouc solution in a thin jet, and heat the mixture, while constantly stirring, until it is perfectly homogeneous. Pour it into greased metallic moulds, where it forms into dark-brown or black plates difficult to break. In using it, it should be melted in a kettle placed in boiling water to prevent its burning, which it is very apt to do, as it is a bad conductor of heat. After it has been liquefied remove the kettle from the water and place it over a fire, where it can be heated, if necessary, to make it more fluid, to 150° C. (302° F.), carefully stirring it to prevent burning.

If possible, the surfaces to be glued together should be heated to 100° C. (212° F.), as the glue can then be slowly applied. The thinner the layer of glue in cementing together smooth surfaces, the better will it adhere. But a somewhat thicker layer is required for rough surfaces, for instance, boards not planed, the excess of glue being forced out by strong pressure. Generally speaking, it is best to subject all articles cemented together with marine glue to as strong a pressure as possible until the glue is congealed.

We are fully convinced by experiments that with the aid of this cement square vats perfectly water-tight can be constructed of boards. Wooden pegs

dipped in the composition should be used for putting the vats together.

An excellent marine glue, which can be melted at the same heat as ordinary glue, can be applied with a brush, sets very quickly, is elastic and perfectly soluble in water, can be made by dissolving 60 grammes (2.11 ozs.) of India rubber in 2 litres (4.22 pints) of mineral naphtha. When the rubber is dissolved add twice the quantity of shellac to the naphtha, place the whole in an iron vessel, apply heat cautiously, stir till well mixed, and then pour out on a slab to cool.

IV.

Gutta-percha Cements.

Gutta-percha Cement for Leather.

	Parts.
Gutta-percha	100
Black pitch or asphaltum . . .	100
Oil of turpentine	15

This cement, which should be used hot, is suitable for cementing all bodies, but adheres especially well to leather.

Cement for Hard Rubber Combs.

A. Prepare a very thick solution of bleached gutta-percha in bisulphide of carbon.

B. Dissolve sulphur in bisulphide of carbon.

The cementing is effected by applying solution *A* to

the fractured surfaces and pressing them together. When dry brush solution *B* over the cemented place.

Elastic Gutta-percha Cement.

Dissolve 10 parts of gutta-percha in 100 of benzine, then pour the clear solution into a bottle containing 100 parts of linseed-oil varnish and unite both by shaking. This cement excels in elasticity, and is especially suitable for attaching the soles of shoes, as it is so elastic that it will not break no matter how much it is bent. To make it adhere tightly roughen the leather on the side to be cemented.

Gutta-percha Cement for Horses' Hoofs.

For filling cracks and fissures in horses' hoofs a cement is required which possesses great resistance to the action of water combined with elasticity and solidity. A mass answering all demands consists of 10 parts by weight of gum ammoniac and 20 to 25 of purified gutta-percha. Heat the gutta-percha to 90° to 100° C. (194° to 212° F.), and then work it with the finely powdered gum ammoniac to a homogeneous mass. In using it soften the cement by heating, and after carefully cleansing the crack in the hoof, apply it with a heated knife. The cement solidifies immediately after cooling to the ordinary temperature, and becomes soon so hard as to allow of nails being driven into it.

V.

Caseine Cements.

Preparation of Pure Caseine.

Although the caseine contained in old cheese can be used, the other constituents, such as fat, salt, and free acid, exert an injurious influence upon the solidity of the cement prepared with it. It is, therefore, best to prepare pure caseine, which is easily accomplished in the following manner.

Put milk in a cool place, and after taking off the cream as long as any is formed, remove the skimmed milk to a warm place to coagulate. After beating the curd, place it upon a filter and wash the caseine remaining upon the filter with rain water until the water running off shows no trace of acid.

To remove the last traces of fat tie the washed caseine in a cloth, and after boiling it in water, spread it upon blotting paper in a warm place to dry. It will shrivel up to a horny mass.

When thoroughly dried pure caseine will keep for a long time without suffering alteration. To obtain the caseine in a form suitable for preparing cements it is only necessary to pour water over a corresponding quantity and allow it to stand for some time. Caseine combines with lime to a hard insoluble mass.

Caseine Cement which can be kept for a long time.

Convert into powder, each by itself, 200 parts of caseine, 40 of burned lime, and 1 of camphor. Mix the powders intimately and keep the mixture in an air-tight bottle. For use, mix some powder with the requisite quantity of water and use the cement at once.

Caseine Cement for Glass.

	Parts.
Old dry cheese	100
Water	50
Slacked lime	20

Free the cheese from rind, and rub it with the water until a homogeneous mass drawing threads is formed. Then stir in quickly the lime powder, and use the cement at once. It unites not only glass to glass, but can also be used for cementing metal to glass.

Caseine Cement for Metals.

	Parts.
Elutriated quartz sand . . .	10
Caseine	8
Slacked lime	10

and sufficient water to form a cream-like mass.

Caseine Cement for Porcelain.

Caseine dissolves readily in solution of water-glass, and forms then one of the best cements for porcelain known. To prepare it, fill a bottle one-quarter full with

fresh caseine, and after filling the bottle with solution of water-glass effect the solution of the caseine by frequent shaking.

Caseine Cement for Meerschaum.

Dissolve caseine in water-glass, and after stirring quickly finely pulverized calcined magnesia into the mass, use it at once, as it solidifies very soon. By adding, besides magnesia, genuine meerschaum finely pulverized, a mass closely resembling meerschaum is obtained, which can be used for manufacturing imitation meerschaum.

Caseine and Borax Cement for Wood, etc.

Rub 10 parts of caseine and 5 of borax to a thick milky mass, and use it like glue. This cement can be advantageously used for pasting labels upon wine bottles, as it neither moulds nor becomes detached in the cellar.

Another Receipt.

Dissolve borax by boiling in water, and pour the solution over fresh caseine. The result will be a clear thick mass of extraordinary power of adhesion, which can be kept for any length of time without suffering decomposition.

Applied to leather, paper, linen or cotton goods, it forms a coat of a beautiful lustre, and for this reason is much used in the manufacture of fancy articles of paper and leather.

Caseine Cement for Glass and Porcelain.

Dissolve 10 parts of caseine in 60 of water-glass solution. Apply the cement quickly, and dry the cemented articles in the air.

VI.

Water-Glass, and Water-Glass Cements.

Water-Glass.

Water-glass (silicate of soda or soluble glass) is found in commerce as a thickly-fluid, tenacious mass. It is generally prepared by fusing 15 parts of quartz sand with 8 of carbonate of soda and 1 of charcoal. The silicic acid combining with the soda disengages the carbonic acid, the expulsion of which is facilitated by the presence of charcoal, which converts it into carbonic oxide. It dissolves readily in water. The solution has a strongly alkaline taste, and possesses the property of being gradually converted, on exposure to the air, to a gelatinous mass which finally solidifies. For this reason water-glass should be kept in bottles hermetically closed with corks. Glass stoppers are of no use, as they are so firmly cemented to the bottle, that on attempting to open the latter, the neck breaks off.

By combining water-glass with cement or burned lime the resulting mass solidifies quite rapidly to a mass as hard as stone, and generally capable of resisting chemical action.

Water-glass by itself is only fit for cementing glass to glass, but combined with other substances it furnishes very durable and solid cements.

Water-Glass Cement for Cracked Bottles.

Select a cork which will fit the bottle air-tight and place it loosely upon the bottle, and heat the latter gradually to at least 100° C. (212° F.) Then press the cork down and apply a thick solution of water-glass to the cracks. In cooling, the air in the bottle contracts strongly, and the pressure of the exterior air drives the water-glass with great force into the cracks closing them entirely so that they cannot be detected.

Water-Glass Cement for Glass and Porcelain.

Stir quickly together 10 parts of elutriated glass meal, 20 of powdered fluor spar, and 60 of water-glass solution, and apply the homogeneous paste at once. In a few days the cement will be so hard that the cemented vessels can be heated without danger.

Water-Glass Cement for tightening Joints of Pipes exposed to a red heat.

Mix 80 parts of pyrolusite, 100 of zinc white, and 20 of water-glass.

This cement fuses at a temperature not too high, and then forms a glass-like mass which adheres very firmly and closely.

Water-Glass Cement for Uniting Metals, etc.

A strong cement, which hardens rapidly, is made by stirring the finest whiting in a solution of soda-glass of 33° B., made so as to form a plastic mass. This can be readily colored to any desired shade. The addition of sifted sulphide of antimony gives a black cement, which by polishing acquires a metallic lustre; iron filings render it grayish-black; zinc dust turns it green, but after polishing, it appears like metallic zinc, and may be employed for the permanent repair of zinc ornaments, etc. Carbonate of copper imparts a light green shade. Other additions may be made, as oxide of chrome for dark green, cobalt blue for blue, red lead for orange, vermilion for scarlet, carmine for violet, etc.

Water-Glass Cement for Marble and Alabaster.

The point of fracture of articles cemented with the following mixture is difficult to find, and the cemented place is much stronger than the material itself. Mix 12 parts of Portland cement, 6 of slacked lime, 6 of fine sand, and 1 of infusorial earth with sufficient water-glass to form a thick paste. The article to be cemented need not be heated. It hardens in twenty-four hours.

VII.

Glycerine and Glycerine Cements.

Commercial glycerine is a yellowish or nearly colorless and more or less viscid liquid having an intensely sweet taste. In combination with lead oxide and intimately worked into it, by heating and stamping, it furnishes very strong and durable cements deserving general introduction, though thus far they have been but little used.

For the manufacture of cements the use of pure odorless glycerine is not required, the yellow crude article, which is much cheaper, answering all purposes. The principal point is to use very highly concentrated glycerine, as otherwise the cements prepared with it solidify very slowly and besides do not possess a proper degree of hardness and solidity.

It is of especial importance to have the lead oxide free from water. To accomplish this, heat it thoroughly and mix it with the glycerine while still hot. Cement thus prepared solidifies very quickly, and can be used for many purposes. It is an excellent material for quickly joining the stones of submarine works.

Glycerine and Lead Oxide Cement.

A cement of great value for many purposes and capable of being used where resistance to the action of water, heat, acids, alkalies, etc., is required, is com-

posed by mixing glycerine with elutriated litharge to a thin, homogeneous paste. For uniting the joints of steam pipes, cementing of wood, glass, porcelain, and also glass upon metal, etc., it does excellent service. It solidifies to a very hard mass in a quarter to three-quarters of an hour. Before applying the cement coat the surfaces to be joined with pure viscid glycerine.

VIII.

Lime Cements.

Lime and Chalk.

Quick lime, slacked lime, and chalk are used for lime cements. Quick lime, which is obtained by burning limestone, combines gradually with the fats to insoluble lime-soaps. Slacked lime, which consists of a combination of lime with water, acts in the same manner.

For the preparation of cements the lime is slacked by placing it in a dish and pouring as much water over it as it will absorb. Good lime, technically called *fat lime,* should eagerly combine with water, evolving much heat, swelling greatly, and crumbling to a light white powder. Over-burnt lime cannot be recommended for cements, as it is difficult to slack, and yields a very coarse powder.

Quick lime exposed to the air until, by the absorption

of moisture and carbonic acid, it is converted into powder, is called air-slacked.

Cements prepared with quick lime will, as a rule, solidify more quickly than those prepared with air-slacked lime.

Chalk is a carbonate of lime consisting of the shells of microscopic animals, and can be readily pulverized and elutriated. In the latter state it is known as whiting.

For the preparation of entirely white cements the use of pure white lime or chalk is absolutely necessary. Yellow or reddish lime contains oxide of iron, and furnishes cements of the same tinge.

Lime Oil Cement for Glass.

	Parts.
Litharge	30
Quick lime	20
Linseed-oil varnish	5

Lime Cement for Joiners, etc.

By mixing 50 parts of slacked lime, 100 of flour, and 15 of linseed-oil varnish, a cement is obtained, which is very suitable for filling in cracks and holes.

Lime Cement for Cracked Clay Crucibles, and Porcelain.

By applying to the cracks a mixture of 10 parts of slacked lime, 10 of borax, and 5 of litharge in sufficient water to form a stiff paste, and drying after heating the

crucible, the cracked places will be united so firmly that the crucible, when thrown to the ground, will generally break in any other place than the cemented one.

This cement can also be used for porcelain capable of standing a strong heat.

Lime and Glue Cement.

Stir air-slacked lime into hot glue. The mass, when cold, gives a very hard yellow-brown cement, especially suitable for attaching metal to glass.

IX.

Gypsum Cements.

Sulphate of lime in combination with water is met with in nature, both in the form of transparent prisms of selenite, and in opaque and semi-opaque masses, known as alabaster and gypsum. By pulverizing the latter and heating to about 150° C. (302° F.), it loses its water, and is converted into anhydrous gypsum or *plaster of Paris*, which, on mixing with water, recombines with it to form a mass of hydrated sulphate of lime, the hardness of which nearly equals that of the original gypsum. When the powder is mixed with water to a cream and poured into a mould, the minute particles of anhydrous sulphate of lime combine with the water to reproduce the original gypsum, and this act of combination is attended with a slight expansion

which forces the plaster into the finest lines of the mould.

By using a solution of alum instead of ordinary water, a plaster is obtained which, although it takes much longer to set than the ordinary kind, is much harder, and therefore takes a good polish.

For preparing cements only perfectly white plaster of Paris should be used, as the gray article possesses but little adhesive power.

Cement for Plaster of Paris Statues.

To repair plaster of Paris statues so that the point of fracture cannot be detected, proceed in the following manner:—

Moisten the fractured surfaces with water by means of a brush until they absorb no more and remain moist. Mix plaster of Paris with water to a thin cream and stir until the heat appearing at first has ceased, which will prevent the conversion of the plaster into a solid coherent mass. Apply quickly a thin layer of the plaster to one of the fractured surfaces, press the other against it until the plaster has set, and, when dry, carefully remove the excess by scraping.

Cement for Glass and Porcelain.

Mix quickly 50 parts of plaster of Paris, 10 of quick lime, and 20 of white of egg, and use at once, as the cement solidifies very rapidly.

Cement for Iron and Stone.

A very useful cement for fastening iron railing into stone is obtained by mixing 30 parts of plaster of Paris, 10 of fine iron filings, and 20 of vinegar.

Plaster of Paris and Alum Cement for Porcelain.

Mix plaster of Paris with saturated solution of alum to a cream. After moistening the fractured surfaces apply a thin layer of the cement, press the surfaces together, wrap a wire or cord tightly around them, and let the article stand quietly for a few weeks. The cement is converted into a mass as hard as stone.

Plaster of Paris and Gum Arabic Cement for Porcelain.

Mix plaster of Paris with a thick clear solution of gum arabic and cement the articles as soon as possible. Although this cement adheres very tightly, porcelain vessels cemented with it cannot be used for liquids.

Universal Plaster of Paris Cement.

Mix 21 parts of plaster of Paris, 3 of iron filings, 10 of water, and 4 of white of egg. This cement is suitable for attaching metal to glass, metal to stone, etc.

X.

Iron Cements.

Iron Cement resisting Heat.

	Parts.
Clay	10
Iron filings	5
Vinegar	2
Water	3

Water and Steam-proof Iron Cement.

	Parts.
Iron filings	100
Sal ammoniac	2
Water	10

This cement commences to rust very much in a few days, and becomes converted into a very solid mass perfectly steam and water-proof.

Cement for Iron.

Mix 65 parts of wrought iron filings, 2.5 of sal ammoniac, and 1.5 of flowers of sulphur, and then add 1 part of sulphuric acid diluted with sufficient water to form a stiff paste. This cement solidifies in two to three days, and rusts, with the parts of iron to be cemented, to an extraordinarily durable mass.

Fire-proof Cement for Iron Pipes.

	Parts.
Wrought iron filings	45
Clay	20
Fire clay	15
Solution of common salt	8

Iron Cement for High Temperature.

No. 1.

	Parts.
Iron filings	20
Clay powder	45
Borax	5
Salt	5
Pyrolusite	10

After dissolving the borax and salt in the water, add and mix quickly the clay powder, pyrolusite, and iron filings, and apply at once. Exposed to a white heat, this cement hardens to a tightly adhering glassy mass.

Iron Cement for High Temperatures.

No. 2.

Mix 52 parts of pyrolusite, 25 of zinc white, and 5 of borax with solution of water-glass to a paste, and use at once. This cement requires to be gradually dried. It will stand the highest temperatures.

Iron Cement for filling in Defects in Casts.

Stir 100 parts of iron filings free from rust with sufficient water to form a thick paste, and press the mixture into the fissures, cracks, etc. The cement becomes solid only after the iron filings become strongly rusted. To free the ingredients from adhering fat, wash them, before mixing, in liquid ammonia.

Iron Cement for Cracked Stove Plates, etc.

Knead 20 parts of iron filings, 12 of hammer slag, 30 of plaster of Paris, and 10 of common salt with blood to a stiff paste, and use at once. Instead of blood, water-glass can be used, it having the advantage of being odorless on strong heating, while blood cement evolves a disagreeable odor.

Iron Cement for Iron Water Tanks.

Knead iron filings with vinegar to a paste. Allow the mixture to stand until it turns brown, and then force it into the joints by means of a chisel.

Iron Cement for Cracked Iron Pots.

Knead 10 parts of iron filings and 60 of clay with linseed oil to a thick paste. Before applying it add a little linseed oil, and allow it to dry slowly. In a few weeks the cement will be so hard that the vessels can be used without danger.

Black Iron Cement for Stoves.

	Parts.
Iron filings	10
Sand	12
Bone black	10
Slacked lime	12
Glue-water	5

Schwatze's Cements for Iron Stoves.

1.

Pulverize as finely as possible and mix intimately 4 to 5 parts of clay, 2 of iron filings free from rust, 1 of pyrolusite, ½ of common salt, and ½ of borax with water to a paste, and apply the cement quickly to the places to be cemented and allow it to dry slowly. This cement will stand a white heat, and resists the action of boiling water.

2.

Mix intimately and as quickly as possible 1 part of pulverized pyrolusite, and 1 of zinc white with solution of water glass to a plastic mass, which solidifies quickly. The power of resistance of this cement, it is claimed, is not inferior to No. 1, though our experiments decide us in favor of No. 1.

XI.

Cements for Chemical Apparatus.

Cements to be used for the above purpose must possess various properties difficult to combine in one preparation. They must be gas-proof, and capable of resisting the action of different vapors and acid fluids. As regards resistance to the action of chemical agents, there is nothing better than caoutchouc, but unfortunately it can only be used for tightening chemical apparatus not exposed to a high temperature.

In chemical laboratories bran of almonds, either by itself or kneaded with water to a thick paste, is frequently used, or rye or wheat bran mixed with a little flour and water. These cements, though very suitable for cementing glass distilling apparatus, are strongly acted upon by chlorine and the vapors of nitric acid.

For small apparatus to be used for the development of flùoric acid, plaster of Paris mixed with a little water can be used as a cement. To make the joint entirely gas-tight, paste a strip of paper over it. Although this cement does not resist the action of fluoric acid for any length of time, it suffices generally for the protection of the workmen during the time the development of the acid is in progress, as, for instance, in chemical analyses, etc.

To cement chemical apparatus exposed to a temperature not exceeding 30° to 40° C. (86° to 104° F.)

paraffine does excellent service; as it possesses the power of resisting the action of the strongest acids and alkalies.

We give in the following a few receipts for cements which have proved reliable.

Linseed Oil and Clay Cement.

Knead 10 parts of dry clay with 1 of linseed oil to a homogeneous mass. This cement will stand heating to the boiling point of mercury.

Linseed Oil, Zinc, and Manganese Cement.

Knead 10 parts of pyrolusite, 20 of zinc gray,* and 40 of clay with sufficient linseed-oil varnish (not exceeding 7 parts), to a plastic mass. This cement will stand a somewhat higher temperature than the preceding one.

Clay Cement for Very High Temperatures.

	Parts.
Clay	100
Powdered glass	2

The glass melts on exposure to great heat and slags the clay to a hard mass. The same effect is produced by adding small quantities of soda and borax to the clay. An admixture of chalk and boracic acid, as in the following receipt, also gives excellent results.

* An inferior quality of zinc white.

		Parts.
Clay	. . . . . .	100
Chalk	. . . . . .	2
Boracic acid	. . . . .	3

Cement resisting Acids.

Melt caoutchouc with double the quantity of linseed oil, and then knead in sufficient bole to form a paste. This cement resists the action of nitric and hydrochloric acids, and can be advantageously used for closing bottles containing them. As it solidifies very slowly, it can readily be detached from the bottles, and used again.

For cement which is to solidify quickly on exposure to the air, add a few per cent. by weight of minium or litharge.

Caoutchouc Cement for Chemical Apparatus.

Cut 8 parts of caoutchouc in small pieces and throw them gradually into a mixture of 2 parts of tallow and 16 of linseed oil previously strongly heated. After effecting an intimate mixture of the constituents by vigorous and constant stirring, add 3 parts of white bole.

Although this cement does not stand a high temperature, it possesses an extraordinary power of resisting the action of acid vapors.

Scheibler's Cement for Chemical Apparatus.

Melt together 1 part of wax and 3 of shellac, and work into the hot mixture 2 parts of gutta percha cut

into very small pieces. This cement will bear considerable heat without actually melting.

XII.

Cements for Special Purposes.

English Cement for Porcelain.

Soak 33 grammes (1.16 oz.) of isinglass in water, then cover it with alcohol and dissolve by applying heat. Next dissolve 16 grammes (0.56 oz.) of pulverized mastic in 33 grammes (1.16 oz.) of rectified spirit of wine, and after mixing both solutions add 16 grammes (0.56 oz.) of pulverized gum ammoniac, and evaporate the whole to a proper consistency over a water-bath. Keep the resulting cement in glass bottles. To soften the cement for use place the bottle in warm water and apply the cement to the fractured surfaces previously heated.

Cement for Attaching Metallic Letters to Glass, Marble, Wood, etc.

Dissolve over a water-bath 5 parts of glue in a mixture of 15 parts of copal varnish, 5 parts of linseed-oil varnish, 3 parts of crude oil of turpentine, and 2 parts of rectified oil of turpentine, and add 10 parts of slacked lime to the mixture.

Cement for Closing the Joints of Iron Pipes.

Mix 5 lbs. of coarsely powdered iron borings, 2 ozs. of powdered sal ammoniac, and 1 oz. of sulphur with

sufficient water to form a paste. This composition hardens rapidly, but if time can be allowed, it sets more firmly without the sulphur. It must be used as soon as mixed and rammed tightly into the joint.

Another receipt is as follows:—

Mix 2 ozs. of sal ammoniac, 1 oz. of sublimated sulphur, and 1 lb. of cast-iron filings or fine turnings in a mortar, and keep the powder dry. When it is to be used, mix it with 20 times its weight of clean iron turnings or filings and grind the whole in a mortar; then wet it with water until it becomes of convenient consistency, when it is to be applied to the joint. After a time it becomes as hard and strong as the metal.

Cement for Uniting Leather and Metal.

Wash the metal with hot gelatine, steep the leather in a hot infusion of nutgalls and bring the two together.

Cement for Leather Belting.

From our own experience we can recommend the following cement as being the best for this purpose. Soak equal parts of common glue and isinglass for ten hours in just enough water to cover them. Bring gradually to a boiling heat and add pure tannin until the whole becomes ropy, or appears like the white of egg. Roughen the surfaces to be joined, apply the cement warm, and clamp firmly.

Steam Boiler Cement.

Mix 10 parts of finely powdered litharge with one part of very fine sand, and one part of air-slacked lime. This mixture may be kept for any length of time without injury. In using it, a portion is mixed into paste with linseed oil, or, still better, with boiled linseed oil. In this state it must be quickly applied, as it soon becomes hard.

Turner's Cement.

Melt one pound of rosin in a pan over the fire, and when melted, add one-quarter of a pound of pitch. While these are boiling add brickdust until by dropping a small sample on a cold stone you think it hard enough. In winter it may be necessary to add a little tallow. By means of this, a piece of wood may be fastened to the chuck, which will hold when cold; and when the work is finished, it may be removed by a smart stroke with the tool. Any traces of the cement may be removed from the work by means of benzine.

Cement for Rubber.

Powdered shellac is softened in 10 times its weight of strong water of ammonia, whereby a transparent mass is obtained, which becomes fluid after keeping some little time without the use of hot water. In three to four weeks the mixture is perfectly liquid, and when applied it will be found to soften the rubber.

As soon as the ammonia evaporates it hardens again, and thus becomes impervious both to gases and to liquids. For cementing sheet rubber, or rubber material in any shape, to metal, glass, and other smooth surfaces, this cement is highly recommended.

XIII.

How to Use Cements.

It is unquestionably true that quite as much depends upon the manner in which a cement is applied, as upon the cement itself. The best cement that was ever compounded would prove entirely worthless improperly applied. We have in the foregoing given a number of cements which answer every reasonable demand when they are properly prepared and properly used. Good common glue will unite two pieces of wood so firmly that the fibres will part from each other rather than from the cementing material; two pieces of glass can be so joined that they will part anywhere rather than on the line of union; glass can be united to metal, metal to metal, stone to stone, and all so strongly, that the joint will certainly not be the weakest part of the resulting mass. What are the rules to be observed in effecting these results?

The first point that demands attention is to bring the cement itself into intimate contact with the surface to be united. If glue is employed, the surface should be made so warm that the melted glue will not be

chilled before it has time to effect a thorough adhesion. The same is more eminently true in regard to cements that are used in a fused state, such as mixtures of resin, shellac, and similar materials. These matters will not adhere to any substance unless the latter has been heated to nearly or quite the fusing point of the cement used. This fact was quite familiar to those who used sealing-wax in the olden days of seals. When the seal was used, in succession, rapidly so as to become heated, the sealing-wax stuck to it with a firmness that was annoying, so much so that the impression was generally destroyed, from the simple fact that the sealing-wax would rather part in its own substance than at the point of adhesion to the seal. Sealing-wax or ordinary so-called electric cement is a very good agent for uniting metal to glass or stone, provided the masses to be united are made so hot as to fuse the cement; but if the cement is applied to them while they are cold, it will not stick at all. This fact is well known to those itinerant venders of cement for uniting earthen-ware. By heating two pieces of delf so that they will fuse shellac, they are able to smear them with a little of this gum and join them so that they will rather break at any other part than along the line of union. But although people see the operation constantly performed and buy liberally of the cement, it will be found that in nine cases out of ten, the cement proves worthless in the hands of the purchasers, simply because they do not know how to use it. They are afraid to heat a delicate glass or porcelain vessel to a sufficient degree, and they are apt

to use too much of the material, and the result is a failure.

The great obstacles to the junction of any two surfaces are air and dirt. The former is universally present, while the latter is due to accident or carelessness. All surfaces are covered with a thin adhering layer of air, which it is difficult to remove, and which, although it may at first sight seem improbable, bears a relation to the outer surface of most bodies different from that maintained by the air a few lines away. The reality of the existence of this adhering layer of air is well known to all who are familiar with electrotype manipulation. It is also seen in the case of highly polished metals which may be immersed in water without becoming wet. Unless this adhering layer of air is displaced, the cement cannot adhere to the surface to which it is applied because it cannot come in contact with it. The most efficient agent in displacing this air is heat. Metals warmed to a point a little above 95° C. (203° F.) become instantly and completely wet when immersed in water. Hence, for cements that are used in a fused condition, heat is the most efficient means of bringing them in contact with the surfaces to which they are to be applied. Another very important point is to use as little cement as possible. When the surfaces are separated by a large mass of cement we have to depend upon the strength of the cement itself and not upon its adhesion to the surfaces which it is used to join; and, in general, cements are comparatively brittle.

The cement forced out of the joint by pressing the surfaces together should be removed while the cement is in a fused state or liquid. This can generally be effected by wiping the surplus off, while after solidification a certain amount of force has to be used which may frequently break the joint.

Oil cements, which generally solidify slowly, have the advantage of being water-proof. In cementing with oil cements coat the surfaces to be joined with linseed oil, or, still better, linseed-oil varnish, but in working with resinous cements apply oil of turpentine, spirit of wine, or a fluid which will readily dissolve the cementing constituent of the cement.

For cleansing the surfaces from grease and dirt place the articles in strong lye and rinse off in clean water without touching the surfaces with the hands. For painted porcelain articles which cannot be placed in lye, it is recommended to brush the surfaces a few times with bisulphide of carbon.

IX.

PASTES AND MUCILAGES.

Preparation of Paste.

Ordinary paste is prepared either from flour or starch, and we may therefore divide it into two varieties, according to the raw material used in its preparation, viz., starch and flour paste.

Starch is an indispensable constituent of certain parts of plants, and plays a very important part in the nutrition of the plant. It is chiefly manufactured from potatoes, Indian corn, and grain. Examined by the microscope, it is seen to be composed of small grains consisting of layers placed one above the other.

Starch Paste.

In stirring starch with water to a thin paste and gradually heating it, it will be observed that at a temperature between 60° and 70° C. (140° and 158° F.) a peculiar change takes place; the thin milk-white liquid becomes transparent, opalizes, and at the same time becomes thickly fluid, in short, the starch is converted into paste. During this process the separate layers of the starch grains become detached somewhat in the same manner as an opening bud whereby they absorb water, and the peculiar mass, called paste, is formed. That paste is not a solution is easily proved by the fact that on attempting to filter starch-paste only water drains off, while the starch remains upon the filter and gradually dries to a horny mass.

Paste left to itself soon decomposes, especially during the hot season of the year; it becomes sour through the formation of lactic acid, butyric acid, acetic acid, and other substances, and loses its adhesive power.

In preparing paste, the following rules must be especially observed: Divide the starch in water by constant stirring so as to form a homogeneous, rather thinly liquid fluid, and then add boiling water in small

portions, stirring constantly. The conversion of the starch into paste is recognized by the thickening of the entire mass and the appearance of opalescence, when it is only necessary to add the required quantity of water to give the paste the desired consistency.

If white lumps are observed, it is an indication that the starch has not been thoroughly mixed with the water, and that certain portions of it have remained dry. Paste containing such lumps cannot be applied with any degree of uniformity, and besides it possesses less adhesive power. Nothing can be done to remedy the evil except diluting the paste with a considerable quantity of water and boiling, with constant stirring, until the mass is perfectly homogeneous.

Starch paste prepared in a proper manner possesses great adhesive power, and, when applied in a thin layer, dries to an almost colorless coating. Pure starch paste is used for many purposes. It serves not only for pasting paper, wall paper, etc., but also for sizing tissues, such as paper muslin, linen, etc., in order to give them lustre, body, and, under certain circumstances, greater weight. To increase the weight of linen, white lead or heavy spar is frequently mixed with the starch.

Flour Paste.

The principal constituent of flour, besides starch, is gluten. It is obtained in a pure state by tying flour in a linen bag and kneading it under water as long as the latter is rendered turbid by particles of starch.

The gluten remaining in the bag is a light brown, very tenacious mass drawing threads between the fingers, and, as regards its chemical properties, is closely allied to albumen and caseine. Gluten, like the last-mentioned substances, shows a tendency to form combinations with lime which gradually solidify, and it can therefore be used for preparing cements. Like albumen and caseine, it speedily putrefies if exposed to the air in a moist state, and in decomposing forms products which have a very unpleasant odor.

Flour paste is prepared in precisely the same manner as starch paste, but while the latter is white, flour paste, even if prepared from the best wheat flour, has always a yellow-brown color. As regards adhesive power it is superior to starch paste, but is less durable.

There are many means to prevent the spoiling of paste. With paste once dry and kept so, there is no danger of spoiling, but if it is alternately exposed to dampness and dryness, as for instance with wall-paper hung on walls not entirely dry, decomposition will unavoidably take place, and the wall paper will become spotted and fall off the wall.

Provided either starch or flour paste is protected against drying in, it can be kept unchanged for many months to be used for pasteboard work or hanging wall-paper to dry walls by adding about 0.5 gramme (7.71 grains) of solution of carbolic acid to every liter (2.11 pints) of paste.

For hanging wall-paper an addition of alum is, gene-

rally speaking, more suitable than carbolic acid. Dissolve, for every litre (2.11 pints) of paste, 10 grammes (0.35 oz.) of alum in hot water and add it to the paste.

In hanging wall-paper the wall is generally first sized with glue-water. By the alum coming in contact with glue an insoluble leather-like combination is formed, which not only resists decomposition, but by far surpasses ordinary paste as regards adhesive power, so that when the paper is to be removed from the wall it has to be scraped and torn off in small pieces, while that hung without previous sizing of the wall is readily removed in large pieces.

But alum cannot be used for preserving a glue solution, as it would cause it to coagulate to a flaky mass. Carbolic acid is, on the other hand, an excellent means for the purpose, but to prevent the empyreumatic odor characteristic of carbolic acid, from making itself too sensibly felt, no more than about one two-thousandth of the weight of the glue solution of carbolic acid should be added.

Shoemaker's Paste.

There is no other variety of paste, which, besides being cheap, possesses such adhesiveness for leather as the so-called shoemaker's paste. With its assistance leather can be cemented not only to leather, but also to woven materials, and to paper, etc. Though the preparation of shoemaker's paste is very simple, it is connected with some disagreeable accessories con-

sisting chiefly in the development of a truly terrible stench.

The paste is prepared by stirring crushed barley with hot water to a thick paste, and adding small portions of hot water so that the temperature of the mass is kept at between 30° and 40° C. (86° to 104° F.). In a few days the mass commences to develop gas which shows at first no odor, but soon the development of gas becomes stronger, and an acid odor is perceptible which in a short time is replaced by a terrific stench, which, as before mentioned, affects the olfactory organs in a most unpleasant manner.

In consequence of the acid and putrid fermentation the pasty mass gradually loses its granular condition and is finally converted into a homogeneous thickly fluid mass of a brown color, which draws threads between the fingers and possesses great adhesive power. When this is the case, decomposition, which otherwise would go on until nothing remained but a watery and acid fluid, is interrupted by lowering the temperature of the paste by ladling it from the vat, or by adding a small quantity of carbolic acid.

To render the stench developed during the fermentation of the paste innoxious, the vat in which it is prepared should be provided with a well-fitting cover, in which is fitted a stovepipe passing into a chimney connected with a kitchen range or furnace in which a fire is frequently burnt.

By kneading shoemaker's paste together with indifferent substances, it can be used as a cement for

various purposes. The substances best adapted for the purpose are burned lime slacked to a powder, whiting, zinc white, pipe clay, ochre, etc.

Gum Arabic, Dextrine, and Tragacanth.

Gum Arabic.

This gum is an exudation from certain tropical species of acacia, and consists essentially of arabine, which has the composition $C_{12}H_{11}O_{11}$. The best gum arabic is that in the form of very pale-yellow brittle pieces; golden-yellow to brownish pieces are not valued as highly, though they give a solution of considerable adhesive power.

Gum arabic dissolves in water, but not in alcohol, and can, therefore, not be employed for cements in the preparation of which solutions of rosins in spirit of wine are to be used.

There are other products of vegetable life, which are also in commerce, called gums, but dissolve partly in spirit of wine. To this class belongs the gum ammoniac mentioned in some receipts for cements. As it is rather expensive it is seldom used by itself as a cement.

Dextrine.

Under the name of dextrine, starch-gum, or leikom quantities of a chemical preparation are brought into commerce, which is largely used by calico printers for thickening their colors, and is substituted for gum

arabic in making mucilages, and in many other applications. Dextrine is prepared by heating starch previously moistened with nitric acid in an oven, and can also be produced by heating paste with malt extract or very dilute sulphuric acid. There is a current anecdote which attributes the discovery of dextrine to a conflagration at a starch factory where one of the workmen who assisted in quenching the fire observed the gummy properties of the water which had been thrown over the torrefied starch.

Commercial dextrine forms pale-yellow to dark-brown masses. These masses dissolve readily in water, and form solutions which, as regards adhesive power, compare favorably with those prepared from gum arabic. The mucilage is prepared by simply stirring the pulverized dextrine with water to a thickly-fluid liquid.

To preserve mucilage unchanged for any length of time, and to prevent the disagreeable formation of mould upon its surface, it is recommended to dissolve some salicylic acid in the water to be used for preparing the mucilage.

Dextrine is usually prepared on a large scale by moistening 10 parts of starch with 3 parts of water acidulated with $\frac{1}{100}$ of nitric acid. The mixture is allowed to dry, and is then spread upon trays in layers about three-quarters of an inch deep in an oven, where it is heated for about one hour to 115° C. (239° F.). Sometimes large drums revolving over a fire are used, or, in order to keep up a uniform temperature, the starch is placed in a copper cylinder suspended in a

vessel with oil which is heated to 180° C. (356° F.). The object of the addition of nitric acid is to allow the starch to be converted into dextrine at a temperature which would be inadequate to effect the transformation of starch alone.

Dextrine is also frequently prepared by allowing germinated barley or malt to act upon starch. Heat 350 to 400 parts of water to about 25° C. (77° F.), and after adding 5 to 10 parts of dry malt, raise the temperature to 60° C. (140° F.). Then add 100 parts of starch, and after mixing the whole thoroughly together, raise the temperature to about 70° C. (158° F.) for twenty minutes. The mass, which appears at first milky and sticky, will gradually become as liquid as water by the conversion of the starch into gum through the action of the malt. To prevent the conversion of the gum into sugar by the diastase of the malt, the fluid must be quickly brought to the boiling point, and, after cooling, filtered and evaporated to the consistency of syrup. In cooling, the mass gelatinizes to a jelly, which after drying is hard and brittle.

According to *T. Blumenthal's* patented method, a drum which can be hermetically closed, is filled two-thirds full with dry starch flour by means of a funnel. A stirring apparatus is then set in motion, and the acid, which is contained in a graduated cylinder, is dusted in a finely divided spray into the drum by means of a small apparatus.

In a drum 1.5 meter (4.92 feet) long and 1 meter (3.28 feet) in diameter, 100 kilogr. (2.20 lbs.) of

potato starch can be uniformly mixed in five minutes with 250 grammes (8.81 ozs.) of nitric acid of 40° B., and the drum emptied by opening the slide. Starch thus treated can be brought into the calcining apparatus without previous drying.

Tragacanth,

or, *gum tragacanth*, exudes from *Astragalus verus*, a tree indigenous to Asia. The term gum is a misnomer, as tragacanth does not actually dissolve in water nor in spirit of wine, but merely swells up in water to a soft gelatinous mass. Tragacanth consists of irregular pieces of a pure white to yellowish color. It is chiefly used for confectioner's purposes, though sometimes as a paste for fancy articles. This variety of gum is found, together with arabine, in the gum which exudes from cherry, plum, almond, and apricot trees, and gives the mucilaginous character to the watery decoctions prepared from certain seeds, such as linseed and quince-seed, and from the root of marshmallow.

Pastes and Mucilages for Special Purposes.

Liquid Paste.

1.

Pour 6 kilogr. (13.2 lbs.) of water and 250 grammes (8.81 ozs.) of white nitric acid over 5 kilogr. (11 lbs.) of potato starch in a porcelain vessel, and allow the whole to stand in a warm place for forty-eight hours,

with frequent stirring. Then boil until the mass is thickly fluid and strongly transparent, and then filter through a close cloth, previously diluting the solution with water, if necessary.

2.

Dissolve 5 kilogr. (11 lbs.) of gum arabic and 1 kilogr. (2.2 lbs.) of sugar in 5 liters (10.56 pints) of water, and, after adding 50 grammes (1.76 oz.) of nitric acid, heat to the boiling point, and mix the fluids No. 1 and 2 together. The paste thus obtained remains liquid, does not mould, and, applied to paper, dries to a lustrous layer. It is especially adapted for envelopes, fine bookbinder's work, etc.

Sugar and Lime Paste.

Dissolve 12 parts of white sugar in 36 of water. Heat the solution to the boiling point and add 3 parts of slacked lime. After allowing the liquid to stand in a covered vessel for several days, stirring frequently, let it settle and then pour off the supernatant thick fluid from the excess of lime.

The paste obtained in this manner has all the properties of a solution of gum arabic, and dries to a lustrous mass.

Liquid Sugar and Lime Paste.

Allow 3 parts of glue to swell in 10 to 15 parts of the foregoing paste, and by heating the mixture to the boiling point, a solution is obtained which does not

congeal on cooling and possesses considerable adhesive power.

On account of the caustic properties of this paste, which are due to its percentage of lime, it cannot be used for pasting colored paper, or leather, as it would destroy the colors.

Improved Paste for Wall Paper.

A new form of paste for attaching paper-hangings to walls, and one which, besides possessing the merit of cheapness, has the advantage of preventing the paper from separating or peeling off, is prepared by softening 18 lbs. of finely powdered bole in water, and then draining off the surplus of water from the mass. Then boil 1¼ lbs. of glue into glue-water, stir in the bole and 2 lbs. of gypsum, and force the whole mass through a sieve by means of a brush. Dilute with water to a thin paste and it is ready for use. This paste is not only much cheaper than the ordinary flour paste, but it has the advantage of adhering better to whitewashed walls, especially to such as have been coated over several times, and from which the coating has not been carefully removed. In some cases it is advisable, when putting fine paper on old walls, to coat them by means of this paste with a ground paper, and to apply the paper hanging itself to this with the ordinary paste.

Paste for Uniting Leather Straps.

Comminute 250 parts of gilder's glue, 60 of isinglass and 60 of gum arabic, and boil in water until a homogeneous solution results, and then add 5 parts of Venetian turpentine, 5 of oil of turpentine, and 10 of spirit of wine.

Fit the ends of the straps together, cleanse them thoroughly, and, after applying the paste, press between hot plates, after which apply pressure until the paste is entirely cold.

Paste for Paper and Fine Fancy Articles.

1.

Dissolve, with the assistance of heat, 100 parts of gilder's glue in 200 of water, and add a solution of 2 parts of bleached shellac in 10 of alcohol.

2.

Dissolve, with the assistance of heat, 50 parts of dextrine in 50 of water, stir solutions 1 and 2 together, strain through a cloth into a flat prismatic mould, and allow it to congeal. For use, melt a piece of corresponding size, and dilute the liquid, if necessary, with water.

Mucilage for Postage Stamps, etc.

Mix 2 parts by weight of dextrine, 1 of acetic acid, 5 of water, and 1 of alcohol.

This mixture is exclusively used for coating United States postage stamps.

Mucilage to prevent the detaching of Postage Stamps and the opening of Envelopes.

Postage stamps can, of course, be easily detached, and postal wrappers and envelopes opened by loosening the gum by moisture. The object of an American patent, by Mr. Fox, of Baltimore, is to meet this evil. Two adhesive compounds are used: one is applied to the flap; the other to the part against which this is pressed. The latter, which is not touched with the lips or tongue, is prepared as follows: About 2.5 grammes (38.58 grains) of crystallized chromic acid are dissolved in 15 grammes (0.52 oz.) of water and 15 grammes (0.52 oz.) of caustic ammonia. To this mixture are added about 10 drops of sulphuric acid and 30 grammes (1.05 oz.) of sulphate of cupric oxide-ammonia, as also 4 grammes (61.72 grains) of fine white paper. The other solution for the flap (which is moistened with the mouth) is obtained by dissolving isinglass in dilute acetic acid (1 part acid to 7 parts water) over the water-bath. When the parts of the envelope, etc., are fastened together, the union is so firm as to resist all loosening influences, such as acid, alkalies, hot and cold water, or steam. The envelope can only be opened by cutting or tearing.

Paste for attaching Cloth or Leather to Table Plates.

Stir 1 kilogr. (2.2 lbs.) of wheat flour to a homogeneous paste with 4 liters (8.45 pints) of water and 20 grammes (0.7 flu. oz.) of finely powdered alum, and boil the mixture, stirring constantly, until it is so thickly fluid that a spatula will stand in it. Allow the mass to cool in a covered vessel. Apply the paste in as thin a layer as possible to the table-plate, place the cloth upon it, and press it down with a roller, working from the centre towards the edges. Do not trim the projecting ends of the cloth until the paste is entirely dry. Leather is moistened on the under side before placing it upon the paste, and treated in all other respects like cloth.

Prevention of Mould in Mucilage.

Solutions of gum Arabic are very liable to become mouldy, and, while the introduction of creasote, corrosive sublimate, etc., frequently used to remedy this evil, is objectionable on account of the danger of poisoning, sulphate of quinine is a complete protection against mould, a very small quantity of it being sufficient to prevent gum mucilage from spoiling.

Very adhesive Mucilage.

Dissolve 30 grammes (1.05 oz.) of crystallized sulphate of alumina in 300 grammes (10.58 ozs.) of water, and add it to a solution of 1 kilogr. (2.2 lbs.) of gum Arabic in 2 kilogr. (4.4 lbs.) of water. This

mixture will afford a mucilage that will fasten lightly-sized paper, printing paper, etc., or wood to wood, paper to paper, etc.

Paste superior to Gum Arabic.

A brilliant and adhesive paste adapted to the uses of manufacturers of fancy articles, painters, etc., is made by dissolving caseine precipitated from milk by acetic acid and washed with pure water, in a saturated solution of borax.

Paste for Labels on Bottles, etc.

An excellent paste for fixing labels on glass, wood, or paper is prepared by dissolving 11 parts by weight of common glue soaked a day before in cold water, 7 parts of gum Arabic and some rock candy in 56 parts of water at a gentle heat, with continued stirring until the mass is uniform. Labels brushed with this and dried will adhere firmly if simply moistened with saliva when used.

Improved Gum Arabic Mucilage.

A serious objection to the use of gum Arabic as an adhesive is found in its showing through unsized paper, and thus producing a semi-transparent blot. It is also attended by the still greater inconvenience that the two layers do not stick together satisfactorily. On this account gum Arabic mucilage cannot be used for attaching paper to pasteboard, nor wood to wood, nor one metallic substance to another, since the gum

soon peels off. All this inconvenience can be remedied by adding to the gum a solution of sulphate of alumina; 2 parts of crystallized sulphate of alumina answering for 125 parts of the concentrated solution of gum Arabic, in the proportion of 2 parts of gum to 5 of water. The salt is dissolved in ten times its weight of water, and the solution is mixed direct with that of the gum solution, which in this condition well deserves its name of vegetable glue.

Strong Adhesive Paste.

An excellent paste is prepared as follows: Four parts by weight of glue are soaked for several hours in 15 parts of water, and then slowly warmed until a perfectly clear solution is formed. This solution is then diluted with 65 parts of boiling water and thoroughly stirred. In the mean time, 30 parts of starch are stirred into 200 parts of cold water so as to form a thin, milky liquid free from lumps. Into this is poured the solution of glue, stirring constantly and heating. When cold 10 drops of carbolic acid are added. The paste made in this way possesses extraordinary adhesive power, joining paper, leather, pasteboard, etc. By keeping it in closed vessels, so that the water cannot evaporate, it may be preserved for years. Where no great strength is desired, flour or starch paste is used, a little carbolic acid being added to prevent souring.

Paste for attaching Labels to Metal.

Take 10 parts of tragacanth mucilage, 10 parts of honey, and 1 part of flour. The flour appears to hasten the drying, and renders the paste less susceptible to damp.

Another paste that will resist the damp still better, but will not adhere if the surface is greasy, is made by boiling together 2 parts of shellac, 1 of borax, and 16 of water. Flour paste to which a certain proportion of sulphuric acid has been added makes a lasting cement, but the acid often acts upon the metal.

Permanent Paste.

To make paste that will keep a long time mix with each 100 lbs. of flour 5 lbs. of alum, 8 ozs. of sulphite of lime, and 2 ozs. of oil of sassafras.

Paste for Leather.

Soak ordinary glue and isinglass in water for ten hours, using no more water than just sufficient to cover the materials. Next bring the soaked mass gradually to the boiling point, and add pure tannin until the solution becomes sticky and assumes the appearance of white of egg. This cement is adapted to putting patches on shoes, etc. Heat before using.

Adhesive Gum from Phosphate of Alumina.

Pulverize natural phosphate of alumina and mix it with 20 per cent. of gypsum, and heat the mixture to a

red heat. The calcined mass is treated with dilute sulphuric acid and heated with steam. Drain off the liquid and compound it with 15 to 20 per cent. of gypsum. Then add water-glass until the free acid is neutralized, stirring constantly and keeping the mixture hot.

A new Paste.

By the following process, which is the invention of F. O. Claus of Danzig, and patented in Germany, a paste is obtained which adheres firmly to glass and metal. Stir 40 grammes (1.41 ozs.) of starch and 320 grammes (11.28 ozs.) of whiting into 2 liters (4.22 pints) of cold water, and add, with constant stirring, 250 cubic centimeters (0.53 fluidounce) of solution of purified sodium hydrate of 20° B. We have tried this paste, and find that, while it is an excellent adhesive for the purposes mentioned, it can also be used for white paper, but not for colored paper, as the color is attacked by the sodium hydrate.

X.

PRESENT STATUS OF THE FABRICATION OF GLUE.

As regards the consumption of glue, it can be justly said that it has enormously increased during the last twenty years, not only because new uses for glue have

been discovered, but also on account of the great and general increase in industrial activity. It is, nevertheless, a fact that, notwithstanding this increased demand, numerous glue-boiling establishments have been forced to go out of the business, and that the price of glue has greatly fallen during the last few years. This may be explained by the fact that small establishments find it impossible to compete any longer with large factories provided with the most modern improvements. The price of glue is now regulated by the large factories of animal charcoal and bone-meal, and they being the most dangerous competitors with the regular glue-boiler, we will devote some space to their discussion.

1. Fabrication of Animal Charcoal and Bone-Meal.

The production of animal charcoal for sugar-houses and that of bone-meal for manure were formerly carried on as separate branches of industry. The bones were calcined in clay or iron retorts and then comminuted; the coarser parts being used as animal charcoal, while the fine dust formed bone-black as a by-product.

Scientists and technologists soon discovered that the portions of animal charcoal derived from the spongy core of the bones were more effective than those from the more solid outer parts. Agriculturists made, at the same time, the discovery that bone-meal reduced by steam, *i. e.*, produced from bones deprived of a

portion of their gelatinous substance, was more quickly absorbed by plants than meal obtained from bones not reduced.

This proved that both industries could be profitably carried on together. The manufacturer of animal charcoal found that by steaming the bones and letting them lie for some time the solid outer envelope of the spongy core became soft and could be separated as a fine powder by a suitable grinding process, while the spongy core remained intact and could be burned to animal charcoal in specially constructed ovens.

A few years since another forward step was taken, and a third branch of industry joined to the others, viz., the manufacture of glue.

By steaming the bones a large portion of the gelatinous substance is extracted. The gelatinous solution and fat are drawn off from the boilers, and the manufacturer of animal charcoal is forced by competition to utilize these materials in order to be able to sell his products more cheaply. But, as the manufacture of animal charcoal is almost without exception carried on on a large scale, some factories consuming several hundred thousand cwt. each every year, it will readily be understood, that these manufactories produce enormous quantities of glue as a by-product, and thus reduce the price of this article of commerce. Generally speaking, only very common qualities of glue are produced, as the manufacturers do not care to go to the trouble of washing, cleansing, and liming the enormous quantities of bones used, their principal object being

the production of animal charcoal for which these preparatory operations are not required. But, should a process of clarifying and purifying the gelatinous solution drawn from the bones be discovered, the entire glue industry could only be profitably carried on in connection with the manufacture of animal charcoal and bone-meal.*

At the present time regular glue-boilers can only compete with the manufacturers of animal charcoal by producing fine qualities of glue and gelatine, and joiner's glue of a particularly good quality from scraps of hide and skin.

2. Production of Glue.

United States of America.

Here the glue industry has reached its highest development. Philadelphia, New York, Chicago, Boston, and Baltimore have large factories provided with the most modern improvements and most perfect arrangements.

The raw material is principally furnished by the large slaughter-houses. Besides the great demand for meat by the population of the large cities, a great

* *H. Gaertner*, the inventor of artificial ivory for billiard balls, etc., claims to have discovered a process of clarifying the turbid soup drawn off from the bones, so that a perfectly clear glue is obtained, whose quality is not in the least injured by the chemicals used.—W. T. B.

number of cattle are killed, especially in the Western cities, for export trade. This being especially carried on during the cold season of the year, enormous quantities of material accumulate during the winter months. More than one million of hogs are killed every year for export.

In Cambridge, Mass., is a glue factory which receives daily 1500 to 2000 gallons of glue-soup produced by boiling bones in the city abattoir. From this liquor, contaminated with blood and dirt, it produces, by treatment with sulphurous acid and concentration in the vacuum pan, a good, pure glue. The factories of Baeder, Adamson & Co., Philadelphia, Wahl Bros., Chicago, and G. Upton, Boston, are very large and well arranged and supplied with the most recent improvements. Many improvements which would be derided as chimeras in Europe have been successfully introduced, and give to the American glue industry an ascendency which will render competition by the European glue-boiler impossible for at least ten years to come.

We give in the following the statistics of the glue industry of the United States as found in the Census Report of 1880.

States and Territories.	Number of establishments.	Capital.	Average number of hands employed.			Total amount of wages paid during the year.	Value of materials.	Value of products.
			Males over 16 years.	Females over 16 years.	Children and youths.			
United States . .	82	$3,916,750	1486	186	129	$600,018	$2,786,342	$4,324,072
California . . .	5	25,000	27	..	2	13,612	23,040	56,000
Illinois	3	465,000	199	75	8	95,700	281,000	563,500
Indiana	4	47,500	30	..	9	10,320	61,250	85,500
Kansas	1	2,500	3	..	..	1,169	250	2,400
Kentucky . . .	2	70,000	40	..	5	8,345	4,400	54,000
Maine.	1	4,000	6	..	..	2,000	11,000	14,000
Maryland . . .	1	4,000	3	..	..	800	5,000	6,400
Massachusetts . .	19	325,400	242	4	2	99,112	280,016	447,112
Michigan . . .	1	3,000	2	..	..	600	1,000	3,000
Missouri	6	36,850	27	..	4	14,120	43,575	77,300
New Hampshire .	1	3,000	4	..	..	1,250	2,500	6,000
New Jersey . . .	4	14,500	11	..	..	5,410	8,400	18,810
New York . . .	9	86,700	297	9	20	129,139	624,123	884,280
Ohio	8	206,600	57	..	26	22,934	40,667	157,700
Pennsylvania . .	13	1,810,400	498	90	51	184,950	1,376,821	1,903,470
West Virginia . .	1	2,000	4	..	2	1,085	800	3,000
Wisconsin . . .	3	30,000	36	8	..	9,472	22,500	41,600

France

may be called the home of the glue-boiler. In no other European country is the glue-boiling industry so well developed. The first bone gelatine was produced in France, and this industry has there been brought to extraordinary perfection.

At the last Vienna exhibition articles manufactured from glue and exhibited by France attracted general attention. Large cities, such as Paris, London, etc., where a large quantity of meat is consumed, are especially favorable to the glue industry. The firms Coignet, père et fils & Cie., Tancrède Frères, and Ed. Lefebvre, Paris, manufacture gelatine and other fine qualities of glue, besides bone-fat, bone-meal, and animal charcoal. All these firms use nothing but bones, and carry on an enormous business.

S. Pujol of Castre, Orne Jaquand, père et fils, Lyons, and other firms produce, besides the various qualities of glue, gelatine, animal charcoal, and bone-meal.

The French glue factories are model establishments. Manual labor is, as much as possible, replaced by machinery, and it is very difficult to compete with French manufacturers, especially as regards the production of gelatine, large quantities of which are used in France itself for the manufacture of numerous fancy articles, such as fans in imitation of mother-of-pearl and tortoise-shell, etc.

H. Pinson, Paris, produces very perfect gelatine

imitations of such stones as malachite, lazulite, aventurine, etc., and also of tortoise-shell and ivory.

Belgium

has several large glue-boiling establishments, the most extensive being that of G. Dewilt & Co., Vilvorde, near Brussels. It employs 200 hands, and uses 4 steam-boilers.

England.

No other country possesses such valuable raw material as England. This consists in the large quantities of sheep bones collected in the large populous cities, and the serons in which many of the colonial products are imported.

The firms of John Green, Freeman Wright, and John Bell & Co. manufacture white and colored gelatine, and excellent qualities of joiner's glue.

Germany and Austria.

In these countries the manufacture of glue, gelatine, animal charcoal, and other by-products has largely increased within the last few years. Generally speaking, the products are of excellent quality, and large quantities are exported to France, the United States, etc. We will mention only a few of the most prominent manufacturers.

Fischer & Schmitt, Hœchst-on-the-Main, and Nied near Frankfort. Both works cover an area of about 5 acres, and employ at present about 140 workmen.

There are in operation 6 boilers, 5 steam-engines, and a water-power of 10 horsepower. The raw material used in the works consists of bones and skin offal, the latter of which is to be obtained in the market, both dry and green.

The annual production is over 330,000 pounds, and consists of various sorts of gelatine from the finest to the most ordinary, and of glue. The waste products of the works are valuable as phosphate of lime and manures.

Otto Lindenhauer, Hanau. The manufactory consists of seven buildings, employs 100 workmen, and has 4 steam-engines. Produces principally gelatine of the finest quality, using as raw material the residues from the bone-button works, working up about 1,000,000 pounds yearly. The waste products are used in making superphosphates, of which 500,000 pounds are produced annually. The fine white gelatine finds application in the kitchen in place of isinglass, and in the clarification of wine and beer, as well as in the dressing of silk and straw hats, and in the manufacture of bristol board, insoluble imitation of tortoise-shell, mother-of-pearl, and in many color mixtures for buttons, etc. The sale of the products is chiefly in Germany, Austria, Russia, Denmark, and the United States.

Bartels & Koyemann, Frohse near Schoenebeck, employ sixty hands and occupy a space of five acres. The manufacture is restricted to the working up of bones from which are produced—

1. Glue of excellent quality, which by preference finds application in wood and textile industries, paper and carpet mills, and in the tightening of petroleum barrels.

2. Bone-fat which after purification is used in the soap factories.

3. Bone-meal which gives by decomposition with sulphuric acid about 2 per cent. of nitrogen and from 10 to 12 per cent. of soluble phosphoric acid.

4. Bone superphosphate containing 20 to 22 per cent. of soluble phosphoric acid, which has met with general recognition, and is preferred to all other superphosphates.

5. Ammoniacal superphosphate made by the addition of ammonium sulphate to the above. It contains 10 to 11 per cent. of nitrogen, and 10 to 11 per cent. of soluble phosphoric acid. It is intended as a substitute for Peruvian guano.

6. Purified phosphate of lime for mixing with fodder. It is highly esteemed by farmers.

At present there are manufactured annually :—

Glue	660,000 lbs.
Bone fat	250,000 "
Artificial manures	11,000,000 "
Refined phosphate of lime . .	550,000 "

W. Suhr, Altoona. The works are occupied in the manufacture of glue, fat, dung-meal, bone-meal superphosphate, animal charcoal, leather, and leather-oils, and use as raw materials, refuse from skins, sinews, bones, pig's feet, bodies of animals, etc. The methods employed differ extremely, corresponding to the

material to be worked, but are not affected by climate, weather or season, so that even in *unfavorable* weather only *one* day is necessary for the drying of the glue. The waste products are utilized as dung-meals.

The glue industry in the remaining parts of Europe is of but little importance.

Italy

does not manufacture sufficient for home consumption, large quantities being imported. Pietro de Cian, Venice, manufactures gelatine products for medicinal purposes, while other firms in Livorno, Turin, etc., produce gelatine and other varieties of glue.

Sweden

has but few large establishments, the larger portion of the glue being manufactured by small glue-boilers and tanners as a by-product.

In *Denmark* the factory of J. Holm & Sonner, Copenhagen, deserves mention.

The production of glue in Spain, Algiers, Greece, Turkey, Servia, and Roumania is very inconsiderable, and the manufacture but little developed. Almost all of the glue and gelatine used in these countries is imported from France, England, and Germany.

China and Japan

produce glue and gelatine of excellent quality, but the rapid development of industries will soon create a larger demand which no doubt will be supplied by the United States.

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